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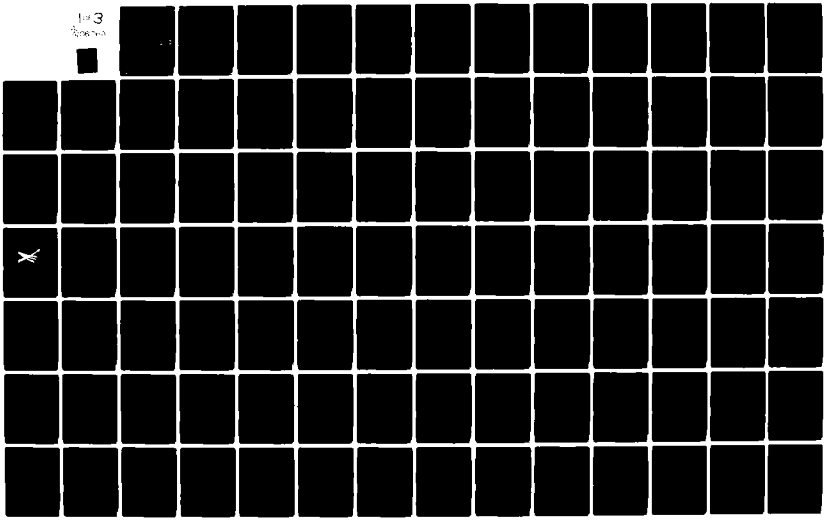

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ABSTRACT

Darwish, Mohammed I., Flynn, Neil T., and Olson, Duane L.
(M.S., Telecommunications)

TIS - Beyond Electronic Mail

Research Project directed by Professor Frank S. Barnes.

This project initially establishes that there is a need for an improved system of information handling. This need has evolved from the growth of knowledge, the speed with which information moves, and the pervasive use of the digital computer. Improved information handling is required to provide timely decision-making data, to help maintain a company's competitive position, and to reduce office costs, transmission costs, and travel costs. Past barriers to solutions have included the cost and inadequacy of the available alternatives as well as certain regulatory and financial factors.

The technology is now available to provide a means of meeting the needs for improved information handling. In media, this technology is seen in microwave, satellite, and fiber-optic developments which allow for the establishment of both private networks and intelligent networks to serve the user who does not have his own network. The technology has also provided a wide variety of equipment to use in solving information needs, including computers--especially the microprocessor--along with word processors, display terminals, private-branch exchanges, facsimile, high-speed printers, optical-character recognition, and voice-recognition equipment.

A telecommunications information system (TIS) is proposed as a concept, using the technology described, as a framework in which solutions to the information handling needs may be met. As defined

and described, the TIS concept would comprise a compter-based, integrated-digital system to provide a variety of services which would go beyond the limited, single-service provisions of so-called "electronic mail." Approaches to be used in implementing a TIS are considered, and a time-frame scenario is provided. Finally, some of the organizational, procedural, and human factors of a TIS implementation are discussed.

This abstract is approved as to form and content.

Signed ______________________
Faculty member in charge of Research Project

TIS - BEYOND ELECTRONIC MAIL

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A Research Project submitted to the Faculty of the
Program in Telecommunications of the University
of Colorado in partial fulfillment of the
requirements for the degree of
Master of Science
Program in Telecommunications

1979

This Project for the Master of Science Degree by

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CHAPTER I

INTRODUCTION

An interdisciplinary approach to almost any aspect of telecommunications encompasses such a broad range of specialties and such vast quantities of information that a comprehensive treatment of the field is impossible. This has become even more true as fields of data processing and telecommunications have increasingly tended towards a single, unified industry. The employment of the coming telecommunications technology, especially in the implementation of integrated systems as will be proposed, draws upon the social sciences as much as the technical. An understanding of antitrust law and the function of regulatory agencies, as well as financial institutions and markets, is also essential. For that reason, a paper of this scope must limit its focus to the authors' views of the most essential elements necessary to achievement of the desired objective. Elimination of other elements, or whole fields of study, is not meant as a comment on the importance of those areas. It is hoped, however, that the elements selected for inclusion will adequately enough reflect the trends in telecommunications so that the reader will be drawn to conclusions similar to those reached by the authors, and that the study will prove useful in outlining the concepts necessary to plan for the use of evolving technology in future integrated-telecommunications systems.

CHAPTER II

THE NEED FOR AN IMPROVED INFORMATION SYSTEM

A. Factors Affecting Information

Three factors, more than any others, have impacted on the role of information in the modern society: the growth in total knowledge has expanded at an exponential rate; the speed with which information moves has become near instantaneous; and the computer has provided enormous improvements in the acquisition, transfer, processing, storage, and retrieval of information. Knowledge growth, information speed, and wide-spread computer applications all were outgrowths of the need to solve earlier problems, but the very success in obtaining new knowledge, increasing communications efficiency, and finding new ways to process information more efficiently, has brought with it new needs, requiring new solutions. First let us examine the three factors which are chiefly responsible for the creation of those new needs.

The Growth in Knowledge

> We have reached a state now in man's learning when the quantity of information being generated in industry, in governments, and in the academic world is reaching alarming proportions. The press euphemistically calls it the "information explosion," but that is not a good term because explosions quickly end their violent growth. The growth of Man's information has no end in prospect, only greater growth.[1] --James Martin

The sum total of all human knowledge, it has been estimated, was doubling every fifty years by the year 1800. By 1950 it was

doubling every ten years, and doubling every five years by 1970.[2] One need not doubt that the end of this process still lies in the future. So important has information become that in at least one country, Japan, a goal of "informationalization" has been recommended. The Japan Computer Usage Development Institute suggested that this transformation from industrialization be set as a national goal for the year 2000.[3]

"Every society has its base, to some extent, in knowledge," Daniel Bell, Harvard University professor, points out.[4] And the quantity of knowledge which exists within a society can have a significant impact on the roles of the individual citizen. In primitive societies one wise old man might well have been the repository for the entire knowledge of the tribe. Thousands of years later, but only very recently in human history, an expert in law, religion, or science might have been able to store and recall from memory much of the known information about a significant segment of human knowledge in his field. Today, however, the lawyer may be expert in some narrow aspect of corporate law--mergers or product liability, for example--while the scientist can address with confidence only a small segment of his own field--the physics of high temperature gases, or laser radiation. And both require access to extensive reference sources. As the total wealth of knowledge increases geometrically, the role which any single individual can play in using that information becomes increasingly narrow, although no less important. Along with the growth of knowledge has come specialization, with a vengence.

Along with the growth in information has come the need to

codify it, to enter it into a permanent record for later recovery. Unlike our wise old man in primitive society, the experts in law and science who specialized as knowledge grew, found a need to refer to authoritative sources other than memory. A few handwritten texts may have temporarily filled this need, but it was the printing press which greatly accelerated the wider availability of knowledge in that it simplified the codification of information. The preparation of a book encompassing the specialist's field of knowledge may well have been years in preparation, however, a time frame intolerable to today's specialist.

> Only recently has technical change become so dependent upon the codification of theoretical knowledge. What is true about all science-based industries of the last half of the twentieth century . . . is that they derive from work in theoretical science, and it is theory that focuses the direction of future research and the development of products.[5] --Daniel Bell

As we move towards the culmination of the industrial society, the previously known facts and trial-and-error methods have less and less import compared with the change derived from moving the theoretical frontiers forward. The theories, and the research based upon them, require codification and rapid access for recall. To lack this ability implies an incapability of functioning, in an arena where whole new fields of technology emerge and are again submerged in a cycle which may be shorter than the time once spent preparing a text on a single subject. Unlike the industrial society, in which capital and labor were the significant factors, "it is knowledge and information which become the strategic and transforming resources of the society."[6]

> Information Resources is a concept like energy resources. Both of these resources are fundamental to the well-being of individuals and organizations in today's world.[7]

Frequently, it is no longer a product but a service which is the outcome of the resources application when information, rather than capital and labor, are the significant factors. As the growth in knowledge moves us towards an information society, it is the information itself which becomes the most important product. Broadly classified, the information industries, including those engaged in manufacturing, accounted for revenues of nearly $300 billion in 1977,[8] but information services alone, by another estimate, will account for revenues approaching $400 billion by the early 1990's.[9] The impact on professions from the growth in knowledge and the specialization resulting from the importance of the information resource is equally significant. Information occupations account for nearly 50 percent of all jobs within the U.S. economy as we enter the decade of the 1980's, while industrial occupations have fallen well under 30 percent,[10] with agricultural employment accounting for the balance. It is anticipated that the growth in knowledge and the importance of information will continue their sharply upward trend for the foreseeable future.

Speed of Information Transfer

> Improved communications has increased the speed and frequency of change. Additionally, in our 'one world' society the *degree* of impact becomes greater. As individuals, corporations or whole economic units throughout the world--rather than from one isolated geographic area--scurry for the same raw materials or react to the same news information, the amplitude of change is heightened.[11] --Mr. Otis T. Bradley

The sheer quantity of information in existence would have little significance to most of us if it could not be transferred. Along with the explosive growth in knowledge, however, has come a

much increased ability to move those quantities of information rapidly from almost any point in the world to almost any other. The improvement can be seen in almost any statistical measure--circuit miles, number of channels, system channel capacities, and so forth. Figure 1 emphasizes this point dramatically. Circuit capacity, in bits per second, on major telecommunications systems grew by two orders of magnitude--from 10^3 bits per second to 10^5 bits per second--in the first forty years of the twentieth century. In the second forty years this capacity skyrocketed by another five orders of magnitude to 10^{10} bits per second in AT&T's helical wave guide (WT4) system. And optical-fiber systems are leaving the lab for commercial use which promise another order or magnitude or two in circuit capacity.

As recently as 1976 the FCC, in official reports, referred to high data speeds as only 4800 bits per second for standard telephone channels and 9600 bits per second for voice grade private lines.[12] These remain standard speeds, and will for some time, but pulse code modulated (PCM) voice channels currently, as in AT&T's Dataphone Digital Service (DDS),[13] carry the equivalent of 56,000 bits per second. Frequently, rates of 4800 bits per second and 9600 bits per second are no longer referred to as "high-speed" data rates. Indeed, Dr. Eugene Cacciamani, Technical Vice-President of American Satellite Corporation, recently classified these as "medium-speed" data, and placed the high-speed data rates as 50 kilobits per second to 1.5 megabits per second.[14] The Department of Defense Secure Voice System operates over the Westar I Satellite between Wahiawa, Hawaii and Stockton, California using two channels

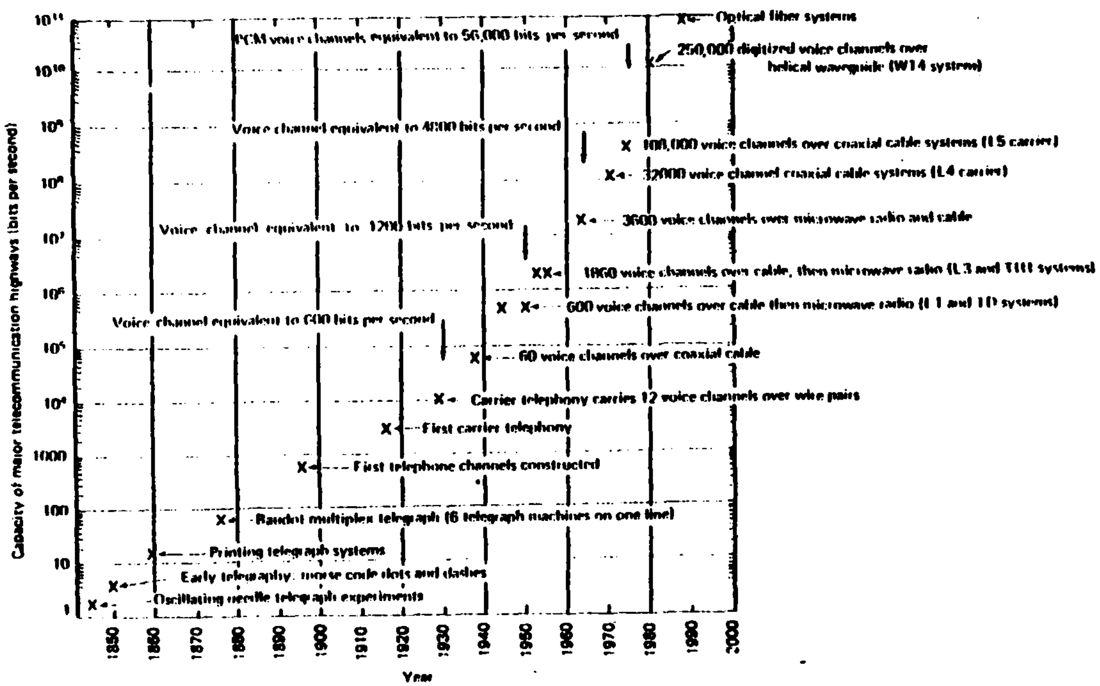

Figure 1. Growth in circuit capacity.

SOURCE: James Martin, Telecommunications and the Computer, 2nd. ed., (Englewood Cliffs, New Jersey: Prentice Hall, 1976), p. 7.

rated at 1.544 megabits per second.[15] And the Defense Meterological Program uses wideband satellite channels to Fairchild Air Force Base, Loring Air Force Base, Monterrey Naval Air Station, and other locations at rates of 2.95 megabits per second.[16] The laser communications satellite which will be launched for the Air Force in December, 1981, has a transmitter with a basic rate of one gigabits per second.[17] Respresentatives of McDonald Douglas Astronautics, contractor for the satellite, expect to achieve multigigabit rates before the satellite is launched, and rates up to sixteen gigabits are possible with the technology being used in the laser transmitter. But when one considers that a gigabit per second is the equivalent of transmitting the entire Encyclopedia Britannica every second,[18] such rates almost lose significance in their enormity.

The exponential growth in the speed of information transfer is reflected in more than the data rates we have quoted, however. HF (high frequency) radio has long provided us the capability to communicate fairly regularly to almost any point in the world so long as the equipment was available and atmospheric conditions were right. What has changed with the technological improvements of recent years is the ability to send masses of data at minimum speed. Whereas former methods permitted us to send *limited* amounts of information in a short-time frame, today's technology makes the quantity of information to be transferred almost irrelevent. With increased speed of information transfer has come an even greater increase in the efficiency of information transfer--with previously little-understood consequences. As Bradley, an analyst with

Alex Brown and Sons, Inc., puts it, "This increased efficiency and speed are not without their counterparts, however; one of which is that *reactions* to communications become faster as well--leading to an increased frequency of change and greater volatility."[19] This increased volatility may be witnessed in day-to-day activities such as the stock or commodity markets, or measured over a much longer span in the rate of change in technological innovation and the increase in total knowledge, as we saw earlier. It might be useful to examine why increased information transfer speeds have a greater impact than was the case when the occurrence of events was reported more slowly. To illustrate, we will use the case in which an event occurs and multiple respondents are to take some action (as the purchase of a particular stock or commodity) based upon news of that event. We will graphically compare the composite reactions to the event when the news is received slowly, over time, perhaps by a variety of means, with the same situation when most respondents have access to the information simultaneously shortly after the event's occurrence.

In both cases, in Figures 2 and 3, we are assuming that an event has occurred at time zero, the origin. In the first case the information arrives slowly either due to the media available or to the rate of transfer via those media. Consequently, the reactions of the respondents are not seen until much later, and the number of reactions at any particular time is not great. In the second case, however, the information reaches all potential respondents very quickly after the event has occurred. In this case the response is limited only by the personal reaction time of each respondent. The

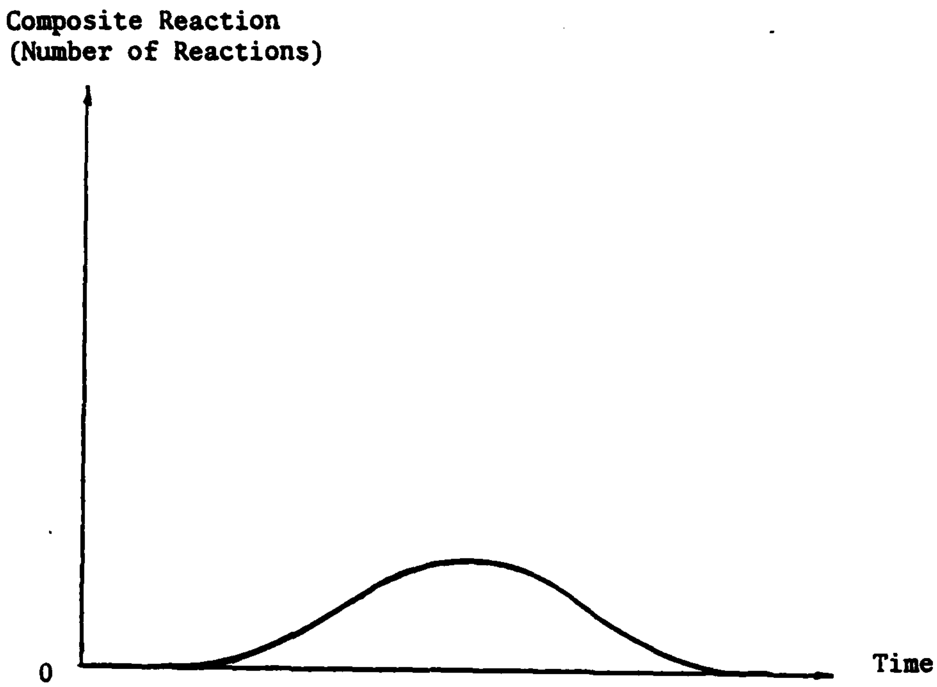

Figure 2. Response when information arrives slowly.

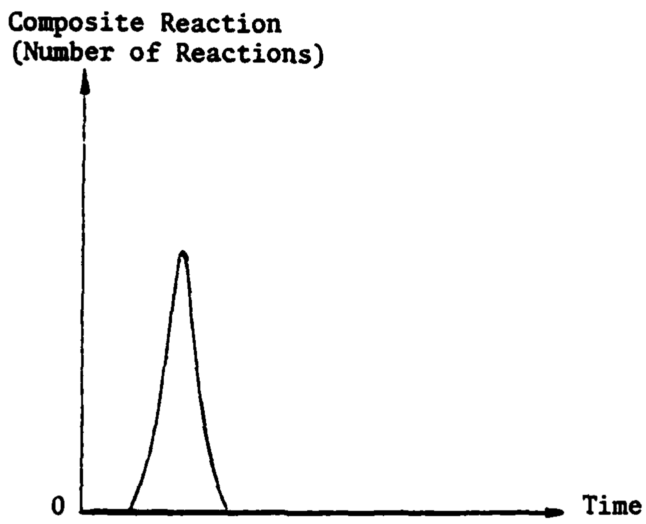

Figure 3. Response when information arrives rapidly.

total number of responses which then occur does not change, but these responses both begin more quickly and occur within a shorter total time frame. The result is a much sharper peak in the reaction count compared with the more diffused reaction in the first case. We may evaluate this situation by simply noting that when information is transferred rapidly, it causes a more rapid change in the environment. What is more, the reaction itself is an event and may cause further reactions among respondents who were not a party to the first event; we then have a rapid "chain reaction." When the original event is a technological discovery, and the reaction is another technological innovation, we begin to understand the reasons for the rapidly increasing growth in total knowledge and in the increased frequency of technological change which Bradley was referring to. We will examine the consequences for the decision maker later, in the next section.

The Computer and Information

Historically, improvements in information handling have occurred irregularly. An improvement in the coding or recording of information was not necessarily accompanied by an improvement in the transmission of the same information. And improvements in transmission have not been matched by a simultaneous advance in recording or storing information. That was true until quite recently, when the computer began to revolutionize all phases of information handling and transfer while computer-controlled mass storage units gave us previously undreampt-of concepts to replace filing systems and libraries. As the Federal Communications noted in its report on "Domestic Telecommunications Policy":

> The modern-day electronic computer is capable of being programmed to furnish a wide variety of services, including the processing of all kinds of data and the gathering, storage, forwarding, and retrieval of information. . . .[20]

At the time that statement was made, in 1976, the number of digital computers installed, of all kinds throughout the world, was a total of 200,000, having climbed from a figure of 30,000 ten years previously and 10,000 units in 1962.[21] Today, computers are so pervasive that it is highly unlikely that any significant percentage of the U.S. population is unfamiliar with them, and certainly all of our lives are affected by them in one way or another. Applications which had been only dreamed of are pouring forth from industry, both to provide new consumer products and to solve many of the management problems in handling information. And the growth process in information technology is apparently only at the threshhold. In speaking of the unprecedented command of information that the computer/communications revolution has given us, the former chairman of AT&T, John deButts, recently stated his belief that "we are only beginning to sense--much less exploit--the potential for improved productivity that resides in information technology."[22]

The extent of applications to date, however, is already impressive--electronic funds transfer, word processing, graphics display, switching, and message systems being the more well-known. Another application of current high interest is in energy management and control. A single small computer can program the heating, cooling, and lighting for a building, determining rate of consumption, compare demand limits, and take corrective action.[23] Two experiments are underway to automate stock market trading, with the possibility of

ending the role of humans on the trading floor.[24] Computers in industry are used to supervise inventories, plan menus, invoice and bill, analyze sales, plan and execute orders, cost out labor, maintain accounts receivable, control pipeline flows, schedule work in process, and numerous other tasks once performed by human labor.[25]

Nor is it only the large industrial corporation which is applying the capability of computer-based systems to solve information handling problems in business. At the other end of the scale, one-man operations are finding ways to apply computer power to give them a tremendous advantage over less imaginative competitors. Sidney Schoeffler founded his Strategic Planning Institute, with an extensive computerized data base, to analyze the important statistics "which account for 80 percent of what causes success or failure" in business (management luck or skill accounting for the other 20 percent).[26] By using the data base as a better way of managing existing information, the former University of Massachusetts professor claims he will "put the consultants out of business." On a still smaller scale, J. Lyman Kiser, a Northwestern Mutual Life underwriter has reported on the use of a small business computer with word-processing capability to replace his secretary, at lower cost, while increasing his production to two and one-half times what it was before he "entered the age of computers."[27] Strikingly, as another example, Mr. Kiser uses his small computer, among other things, to pull 800 files, by birth date, in less than two minutes, a task that formerly occupied a day and a half of secretarial time.

For every manager the importance of the computer in these examples should be self-evident. It is already being widely used to cope with large quantities of data, and it is speeding up the flow of information vastly. In fact, the very success of the computer has fostered a new set of needs for the decision maker, a need to be continuously aware of the capabilities of the new computer-based technology and a need to find ways to apply that technology. Today's rapidly changing environment may not be so forgiving of management failure to understand, acquire, and apply this technology as might have been the case in the days when new systems of information handling evolved more slowly. Like Professor Schoeffler's competing consultants, the laggard may well be "put out of business."

Management needs to be aware of another aspect of computer availability which will cause significant changes in the way he provides his services or products to the market. The consumer, in home or office, is himself becoming conversant with the power of the computer and the improvements it provides in better products and more convenient services. If the market becomes more and more computer-based, those who intend to interact with that market will find a need to insure that they have equivalent capability.

The evidence seems to indicate that the market, both in the home and in business, is just now entering the rapid expansion stage, and the best indication of this may be in statistics on the microprocessor, sometimes called the "computer-on-a-chip." If the expansion of the computer is destined for the small business and

home markets, the trend will be seen in the sales of these minature miracles of silicon rather than in the sales of the large main-frames or even the minicomputers which serve governmental and larger corporate markets. And this is, in fact, the case. Sales of microprocessors reached $135 million in 1978 and will grow to an estimated $670 million in 1982, according to a prediction by International Data Corporation,[28] with further growth to $1.5 billion by 1987 as projected by Arthur D. Little.[29] The projected sales expansion in dollars, however, does not begin to reflect the actual quantities of the microprocessors being shipped, since the cost of the individual device is falling so drastically. The growth in physical quantities, is thus of greater significance. In 1976, a year in which the FCC was reporting a total installed base of 200,000 digital computers, worldwide, shipments of micro-processors reached 2.3 million.[30] According to Dataquest, this volume rose more than tenfold to 27 million units in 1978, with estimated shipments doubling again to 57 million in 1979 and rising to more than 100 million in 1980.[31]

The rapidly decreasing cost of microprocessors, as low as two dollars per unit in some cases, and approaching one dollar, in volume purchases,[32] is putting computing power into the home--chiefly in home entertainment devices, calculators, and home computers. Already microprocessor-based electronic games are accounting for an estimated 45 percent of revenues at Milton Bradley during 1979 and at Parker they reached 25 percent of 1978 revenues, an increase of ten times over the prior year.[33] Arthur D. Little senior consultant, Frank Seabury says,

"In a few years we're not going to be able to really distinguish between a programmable TV game and a home computer."[34] Thus, the almost unexpected penetration of the games market by microprocessors has placed computers widely in homes even where there was no conscious intent to purchase a home computer.

Home computers themselves, meanwhile, apparently will not wait even the "few years" Mr. Seabury anticipates for the development out of electronic games. Many people, and not only the hobby buffs, are accounting for an increasing percentage of sales at several companies, and one, Tandy Corporation, "can't begin to meet the demand for its floppy disk drive", one of the more popular accessories.[35] New entries are being announced. Texas Instruments, already riding its success in digital watches and programmable calculators, entered the home computer market with its 99/4 model in 1979 after deciding not to wait for FCC approval of its lower priced 99/3 model.[36] The lower-priced model can be hooked up to the home TV set, while the 99/4 comes with its own display screen.

A recent Business Week article noted that "Bell is speeding up development of new communications systems that could connect the home to distant computerized data bases to deliver a wide variety of educational, entertainment, and financial services through both video and voice communications."[37] The future applications for the home computer are only beginning to be guessed at, but their use in school studies is an indication that a new generation, unawed by equipment which has existed their entire life, will control the future direction of computer use in the home. David Gold, a California-based consultant formerly with Gnostic Concepts, has

observed that "kids aren't waiting for high school to get into computers. They are starting with them in grade school, and by the time those kids are in high school, they will want their own computer."[38] Computers can be expected to be as much an accepted home appliance for them as the TV or radio is for the present generation. Computer usage in the home will be, perhaps already is, a factor to consider seriously for businesses concerned with serving the consumer market.

No less a factor for the present is the small business market. Small business is a term that can be interpreted differently. U.S. News and World Report uses the criterion that the firm have less than 100 employees to identify 10.2 million companies, 96.7 percent of all nonfarm businesses, who employ 58 percent of all private, nonfarm workers and account for 43 percent of the gross national product.[39] Elsewhere we have used the Bureau of the Census classification of revenues less than $10 million to identify 7.4 million (out of 7.5 million) such firms in existence in 1978.[40] The $135 million in 1978 sales of microcomputers, at prices less than $1000 up to $20,000, was largely within this market.[41] For the 1980's, microcomputer sales are being targeted at companies with annual sales of less than $1 million.[42]

The microprocessor, among the important computer group, may well be the most significant single product to affect the decision-maker's markets. The computer, evolving to meet the need for information handling capability, has created a much more complex information world with which to deal, and astute management will seek new and innovative ways to use this tool to meet the challenges

which have arisen from its earlier use.

B. Why The Need?

Information and Decision Making

For the decision maker, information needs have three critical, physical aspects, aside from the form of the information, which we will not address here. These are:

a. The location of the information

b. The quantity of the information

c. The speed of information transfer

These three aspects impact on the decision-making process in quite different ways.

The problem of information location may or may not be significant depending upon how accessible that location is. If the information is accessible within the time frame in which its use is required, the physical location may have little significance. If, for example, the required information is a local phone call away, the fact that the decision maker does not have the facts immediately at hand is of little importance. If, however, the required information concerns an insect infestation in the cocoa crop in Ghana or an impending frost in the coffee fields of Brazil, where communications facilities are less available, information location would suddenly take an immense significance.

The sheer quantity of information available today causes problems for the modern manager which his counterpart in previous decades encountered only to a much lesser degree. Of all the information available, some will be essential to the decision-making

process, and some will not. Even after selection, the pertinent facts may represent a rather large quantity of data in many cases. If all are required for a rational decision, while the quantity of data which can be transferred within a given time frame is limited, the information may have limited value, or none at all. In such a case, the location of the information would have been irrelevant, whether in the next city, the next state, or another country.

While it is discussed last, by no means is the speed of information transfer last in the order of importance among the physical aspects of information transfer. To the contrary, if information can be moved from where it is located to the place where it is to be used, in the quantity required, within the desired time frame, then location and quantity become subordinated to speed to a large degree, as we saw to some extent in earlier sections.

The modern business or government office has a wide choice of media and methods of information transfer. These include mail, telegram, telex, facsimile, telephone, and--increasingly--electronic-message systems, ranked here by the expected speed each offers in transferring information. The choice among the alternatives in the actual situation will be on a cost-effectiveness basis, considering the time value of the information. Information with a low-time value will, perhaps, be sent most cost effectively by the U.S. Postal Service in the form of a letter or document package, while information with a very high-time value--damage to the Ghana cocoa crop or frost in the Brazilian coffee fields--might be transferred by the most expeditions means possible, regardless of cost. But for purposes of illustration, we will ignore the cost factor

and concentrate on the impact which the same decision will have when based on information received at different times over an extended time span. For our example, we will again use the case in which there will be multiple respondents to a single event, with a high-time value placed on the information, as with the Rothschild's information brought by carrier pigeons, on the defeat of Napoleon at Waterloo. Figure 3 in Section A illustrated the sharp reaction of decision makers in the stock market as the news arrived by conventional means. By decreasing the time frame (the scale of the X axis) we can obtain Figure 4, which depicts the number of decisions occurring over time as the same information reaches the various respondents at different times. Any number of impediments could have caused the delay in receiving the information by the late responders, some of which will be discussed in the following chapter. Figure 5 is then derived from Figure 4, and simply shows the cumulative decisions, in percent, which are made, based upon the arrival of information. It is assumed that all will eventually respond, and the only difference in their response is the time factor. Finally, Figure 6 depicts the value of the information we are assuming for illustrative purposes. Here we are assuming that the value of the information is inversely proportional to the total number of people who possess the information, and that when all possess it the information no longer has value. The reader will note that Figure 6 is roughly the mirror of the cumulative decisions graph. While this assumption will not always be entirely valid, it is a close enough approximation to many real life situations, with which we are all intuitively familiar, that it will serve our purpose.

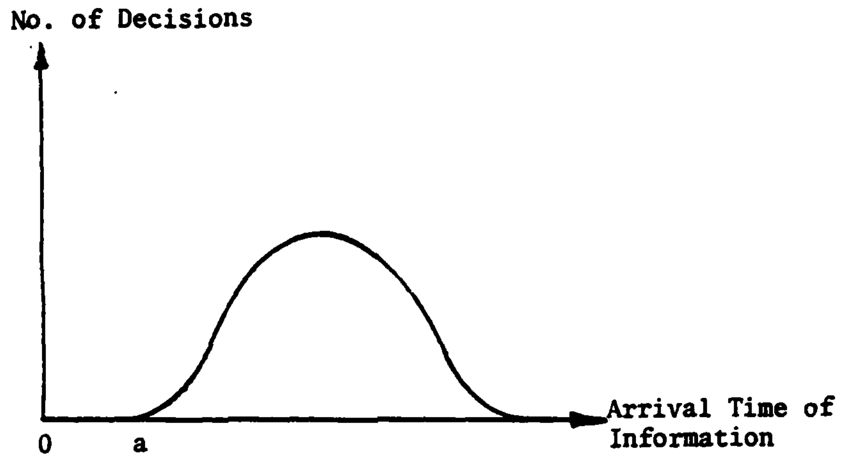

Figure 4. Decisions based on information received

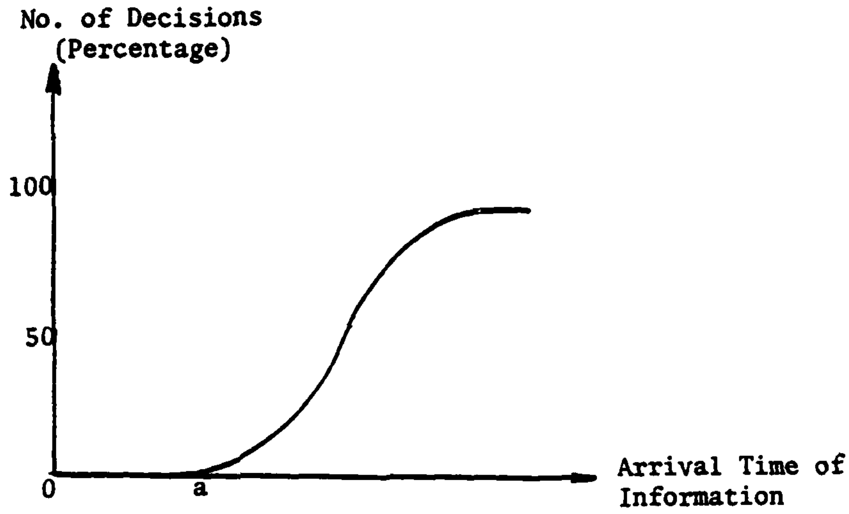

Figure 5. Total decisions (cumulative)

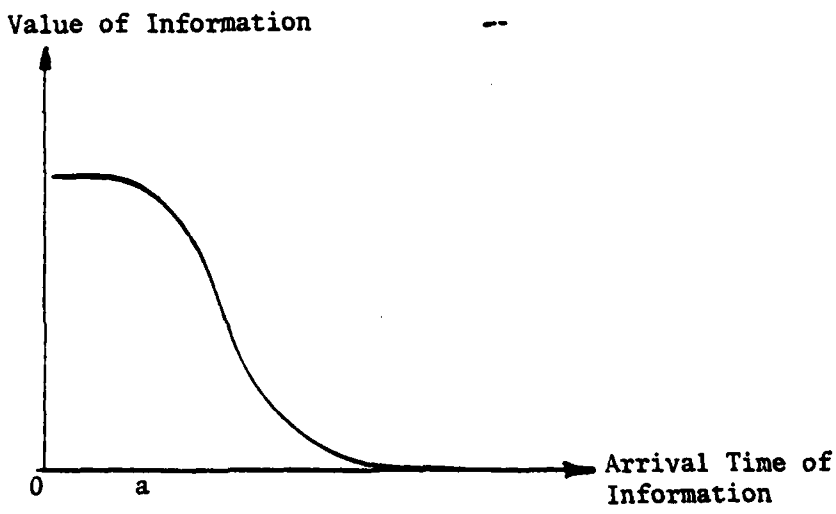

Figure 6. Time value of information

An event occurs at time zero (the origin), and point "a" on the X axis of all graphs represents the initial arrival of information concerning the event. Those responding most rapidly after point "a" will make their decision while the value of the information is still near its peak value. It is clear that information does have a time value and, consequently, the speed of information transfer can have an enormous impact on decisions which are time sensitive.

Competition

In the real world situation, the manager will be concerned not only with the relative values of information as has been illustrated here; the absolute dollar value involved would be much more important. For those decisions which involve information with a high value in both relative and absolute terms, however, the decision maker in a competitive environment must insure ahead of time that his resources include the ability to get all the information he needs, from wherever it may be located, within a time frame that allows him to act. He can be certain that his competition will be attempting to obtain its own high-value information as soon after an event as is possible. The value of advance information in the foundation of the Rothschild fortune has often been cited. Carrier pigeons were used to carry the news of the defeat of Napoleon at Waterloo, and the Rothschilds used that information to make some very profitable stock market decisions.[43] Those who received the information later responded as they had access to the news, and the impact of their reaction, diffused over time, did not have the weight of the Rothschild reaction.

It is possible to graphically portray the retlative value of information over time when there are multiple respondents such as in our example. This value is depicted in Figure 7. Here, assume that an event has occurred at time zero, the origin. The Rothschilds received information on the event and the value of that information was extremely high (Y axis, left scale), and it remained high so long as no others possessed the same information. As the percentage of respondents increased (Y axis, right scale) because they required the same information, the value of that information to each decreased proportionally to the delay involved in their receiving it. For many cases, especially in the business world, our example is close to reality. The value of having some types of information ahead of the competition can be as large, relatively, as it was for the Rothschilds.

Many knowledgeable people see the value of information continuing to increase. Robert S. Magnant, graduate of the University of Colorado Telecommunications Program and presently with the U.S. Army Communications Command, concluded in an address at the Intelcom 79 convention that ". . . information is superseding energy as the mechanism of power."[44]

The value of the decision made is highly dependent upon the speed with which the information reached the manager to enable him to make a decision. The chief difference in the situation between that of the Rothschilds and the modern manager is that the time frame, in which a decision has high impact and high value, has shortened drastically. When news normally took days or even weeks to move from one country to another, an advantage of hours was of

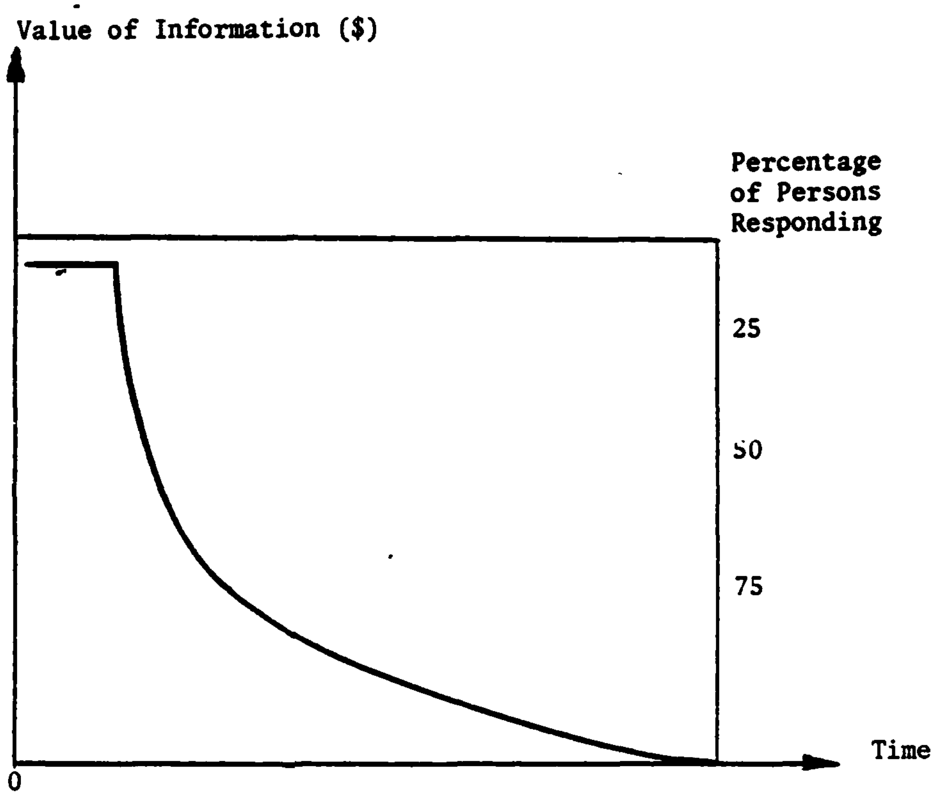

Figure 7. Value of information over time

great significance. The modern manager can still obtain a relative advantage, but the speed of information in today's shrinking world may mean that the advantage, if any, will be measured in minutes. The result is the somewhat incongruous situation in which the wider availability of almost instantaneous information has created a need for still faster access to information.

Where this process of increasing quantities of information being transferred, from almost any location to almost any other, at ever increasing speeds will end, we cannot know. Certainly no end is in sight, and perhaps there is none at all. Since time advantage is relative, the process of time reduction between event occurrence and possible reaction may simply continue the trend--where the reduction from days to hours, and then from hours to minutes, was significant in the past, the competitive advantage in the future may be measured in fractions of a minute. What is certain, in an environment where information transfer speeds are increasing, and where the impact and value of that information is increasingly greater, is that the decision maker who has not made adequate provision for information transfer has also not insured his organization's long-term survival.

Office Costs

> Many organizations now realize that they must begin to move toward the automated office if they expect to stem the rising tide of office costs and still process the growing work loads being placed on them.[45] --Michael D. Zisman, MIT

The 44.8 million white-collar workers employed in the United States as of 1979 represented the major national occupational group, 50 percent of total employment, and accounted for 66 percent

of national payroll costs.[46] Frequently cited statistics indicate that productivity gains in the factory have far outstripped those in the office in recent years. Over the past decade productivity has risen 90 percent for the factory worker, while office worker productivity has climbed a miniscule 4 percent. Further, office costs are expected to double by 1986 from their 1978 level.[47]

It is generally agreed that part of the problem concerning productivity of the office worker, is the low level of capital investment per employee compared with that for the factory worker. The usually cited figure for the investment per factory worker, (originally from the June 30, 1975 issue of Business Week) is that $25,000 of capital is invested for every factory worker.[48] While the amount of capital invested per office worker is not a matter of agreement among authorities in comparison, it generally is recognized as being quite low. Professor Zisman, writing for the Spring 1978 Sloan Management Review quotes authorities showing a range of 2000 dollars[49] to 6000 dollars per office worker. If we accept the higher figure, from Strassman's Harvard Business Review study--"Managing the Costs of Information"--as being the more authoritative, the investment per office worker is still quite low compared with that for his factory counterpart.

Burns has made an interesting point concerning cost trends in office labor communications and computers.[50] While office labor costs are rising 6 percent per year, communications costs are falling 11 percent annually, computer logic costs are going down by 25 percent per year, and computer memory costs are dropping even more sharply, at a 40 percent annual rate

(See Figure 8). With the cost/benefit trend favoring machine intelligence over human by a geometrically increasing rate, it is not surprising that the need to control the soaring labor costs of the office are being reflected in projections for sharply increased future capital investment per employee. Edward Scott, Assistant Secretary for Administration, U.S. Department of Transportation projects a figure of $8,000 per employee by 1985 from a base of $2000 per employee in 1975.[51] Zisman cites a Stanford Research Institute study as the basis for a projection of $10,000 of investment per office employee by 1985.[52]

A measure of the trend in office costs can be seen in the estimated cost of a business letter over the past fifteen years. From a cost of $2.44 in 1965,[53] the business letter had risen to $3.79 in 1975.[54] By 1978 the cost had risen to $4.75 per business letter,[55] and estimates of more than $5.00 may be seen in current publications.[56] By contrast, the cost per hundred thousand computer calculations has fallen from $1.25 to less than one cent over the past twenty years.[57]

Rapidly rising office costs are also reflected in the use of forms. As of 1976, between 80 and 400 billion forms[58] flowed through U.S. organizations, the majority of them in support of business needs. Forms sales grew from $50 million in 1940 to $2 billion in 1976 and more than $3 billion estimated for 1980.[59] Much of this growth in the use of forms, of course, is in support of business efforts to meet increasing government requirements at the Federal, state, and local levels, but the need to codify the vast amounts of information resulting from an explosive growth in

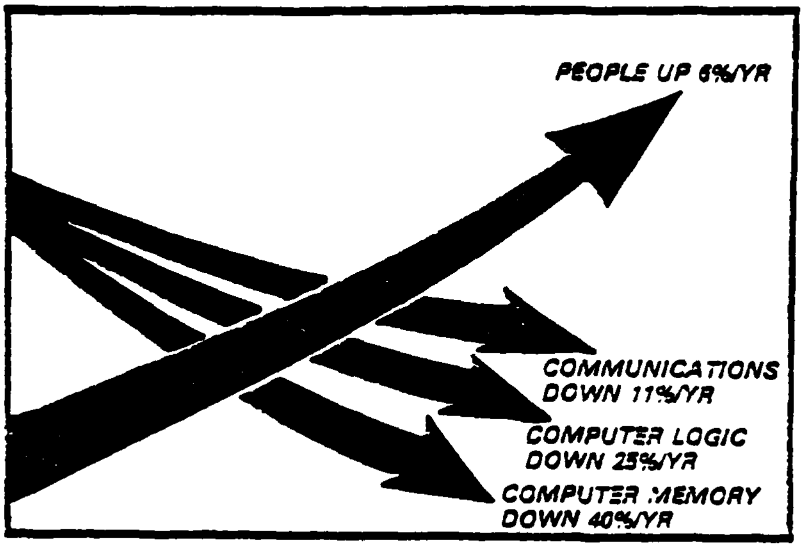

Figure 8. Increased personnel cost versus decreasing telecommunications cost.

SOURCE: Edward W. Scott, Jr., "Multifunction Application at a Medium/Large Site," report to Automated Business Corporation/International Data Corporation's Executive Conference (Scottsdale, Arizona, [April 1979]), P.E.S.-7.

total knowledge, a trend which is not expected to abate anytime in the forseeable future (See previous Section I, Information Growth). So prevasive have forms become in the typical office that an estimated 75 percent of all office clerical labor is devoted to handling them.[60]

Interoffice communications of all types are much larger than just the use of forms would indicate. Formal correspondence within company sites is much larger, for example, than formal correspondence to other company locations or to other companies. While many analysts have concentrated on the figure of 70 billion pages of texts transmitted annually among business and government (less than 500 million by electronic means)[61] Panko, of Stanford Research Institute, cites authorities showing that formal inter-office correspondence is two-to-four-times larger than postal correspondence.[62] Nor does this give us any solid indication of the volumes involved in other types of informal interoffice communications such as memos, bulletins, and simple notes, which may well involve much greater unit numbers than more formal letters and documents. The number of copies made could perhaps serve as one further measure of the volumes involved in interoffice written communications. Extrapolating from figures available on the early 1970's,[63] we may be sure that the number of copies made on convenience copiers and duplicators now exceeds 500 billion (or one-half trillion). When one sums up these forms of written communication, the impression one gets is a sea of paperwork, growing larger in geometric fashion until it inundates the office workers trying to cope with it. If trends of recent decades were to continue,

without finding new ways to cope with this flood of paper, the impression of today might turn out to be the reality of the future.

Yet, according to Edwards, of Bell Canada, 39 percent of the daily activity of white-collar workers in general consists of oral communications.[64] Part of this oral communication, of course, accounts for some portion of the written communication. Dictation eventually results, generally, in written communication. A telephone call may prompt a note or memo, either simultaneously with the call or later as a result of the call. A meeting may consist of one or more speakers while notes, and further written communications later, are produced by several others attending the meeting. The time spent in oral communications may thus not provide an adequate measure of the cost of that communication. Still, a rough approximation may be made by using Edward's estimate of 39 percent of daily office time. Office labor costs in 1974 totaled $376 billion[65] and subsequently have been increasing at a 6 percent annual rate to more than $530 billion by 1980 (author's extrapolation). If one accepts the proportion of labor time spent in oral communication as a valid estimate of the cost of such communication, the resulting figure exceeds $200 billion. This figure is low by at least the amount of the cost of equipment used to support oral communication, including telephones and dictating equipment.

Aside from the direct costs attributable to the communications themselves, there are associated costs which may add greatly to the total. We might categorize three of the major types of such associated costs as:

1. Communications preparation

2. Conversion of communication form (media transformation in Bair's terminology).[66]

3. Communications storage (media management, again in Bair's terms).[67]

Communications preparation includes such things as addressing, labeling, dating, signing, formatting, typing, sealing, stamping, referencing, copying, correcting, coordinating, and initial distribution.

Conversion, anything which involves changing the medium in which the message originated, includes the transformations which are necessary from speaking to writing, from handwriting to typewriting, from data form to hard copy, from local memo copy to formal mail correspondence, and so forth.

Storage of communications or information has always presented a problem since the first man crudely drew a charcoal picture of the hunt on his cave wall. Today, as has been the case for decades, we continue to store the records of written communication in more-or-less organized file cabinets, although more and more information is ending up in the electronic mass storage media--tape, disc, drum, and perhaps active memory. Retrieval from storage is part of the storage problem for our purposes.

The cost of these communications-associated activities, plus the unpredictable, time-consuming activities which hamper, delay or complicate any activity, has been estimated. Calculated on the basis of the labor costs involved, these activities may have amounted to as much as $62 billion in 1974,[68] which, if adjusted for an annual 6 percent increase, would total $88 billion in 1980.

The low rate of investment per office employee and the consequent lagging productivity from the office sector, cited earlier, have resulted in a sharp rise in office overhead costs as a percentage of all company costs. In the 1960's, office overhead represented about 20-30 percent of all costs, but by the 1970's they represented 40-50 percent.[69] This is not to say that the $2000 to $6000 of investment per office employee is an inconsequential sum, considering the fact that more than 50 percent of the U.S. labor force represents white-collar employment.[70] But certainly the relative size of the investment per employee has been small compared with that in the factory where productivity gains have been more dramatic.

Aside from the low absolute level of investment per employee, productivity in the office may be lagging because the investment which has been made was not made in the most productive way. To see why this is so, we will first examine the composition of office labor costs, as depicted in Figure 9, which has been adapted from data presented by James Bair in the January-February 1979 issue of Business Communications Review.[71] It should be noted that secretarial and clerical costs represent only 34 percent of all office labor costs, while professional and managerial labor costs amount to 66 percent of office labor costs.

According to Bair, 95 percent of a manager's time is spent in communicating (oral communication, 75 percent and written communication, 20 percent),[72] and nonmanagement professionals spend 63 percent of their time communicating (37 percent oral and 26 percent written).[73] The secretary spends approximately 20 percent of

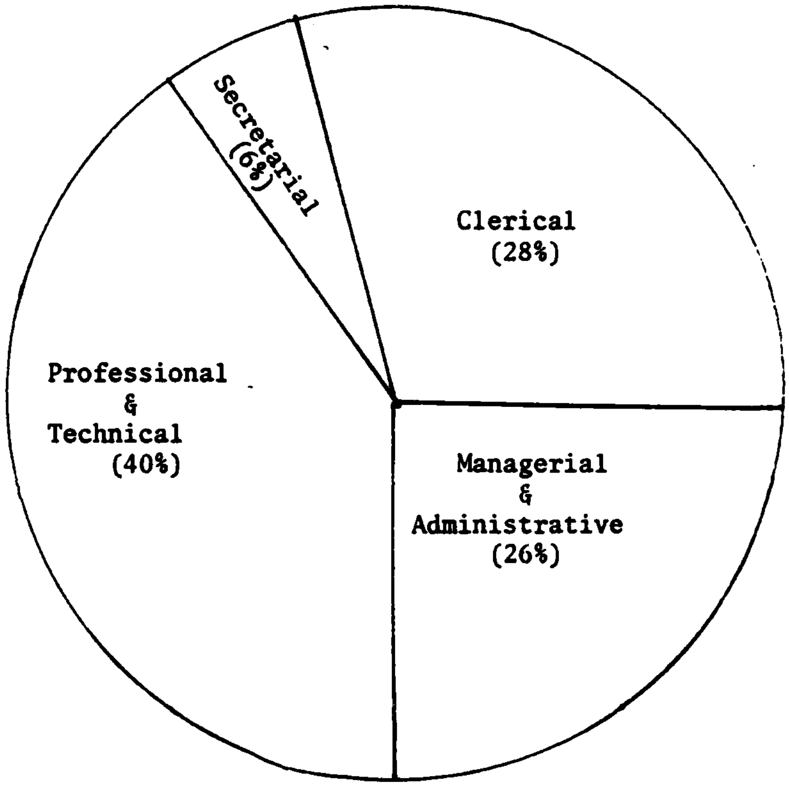

Figure 9. Distribution of office labor costs

SOURCE: James H. Bair, "Communication In the Office of the Future: Where the Real Payoff May Be," Business Communications Review, January-February, 1979, p. 5.

available time on typing tasks, according to Bair's sources.

If the figures are accurate, typing accounts for approximately 1.2 percent of all office labor costs, while managerial and professional communications account for nearly 50 percent of all office labor costs. Given this 40-to-1 ratio between typing costs and the costs of managerial and professional communications, one would expect to see an enormous difference in investment, in favor of the latter over the former. Instead, a considerable percentage of office investment--typewriters and, more recently, word processors--has been spent to reduce secretarial time spent in typing. This is not to say that the investment in typing and word processing equipment is wasted--they are in fact cost effective. Bair's work, however, suggests that the more productive use of the same capital would be found in systems which make managerial and professional communications more efficient. Reducing office typing time by 50 percent, for example, would produce far less total cost savings than would a reduction of 2 or 3 percent in managerial/professional communications time.

Further, in-depth analysis is need in this area. If typing is the bottleneck which is preventing more efficient executive communications, then word-processing equipment may prove to be far more cost effective than a simple calculation of secretarial-typing time would indicate. Dictation equipment, representing an estimated half-billion dollar market in 1982,[74] may aid in speeding up the typing process, but may also make more efficient use of the executive's time by eliminating the delays in awaiting secretarial availability for dictation. If that is the case, capital investment

in the office equipment area, which appears primarily directed at the miniscule percentage of office labor costs that typing represents, may in fact be far more cost effective, upon further analysis, in reducing the inefficiencies in the managerial/ professional communications area. Other investments which are directed primarily at improving the speed and effectiveness of managerial communication, however, could prove to have a much larger benefit to cost ratio, even if there are no secondary advantages in secretarial/clerical efficiency. An ideal system would be one which greatly improved executive communications and, at the same time, reduced the time required for communications preparation, media conversion, and information storage by the secretarial/ clerical staff.

The implications are clear--there is a critical and growing need to control office costs, as Zisman and Bair point out, and these costs will be brought under control only by increasing the productivity of the office worker. That productivity will be gained only through a much greater scale of investment per employee than in the past, and much of that investment will have to be targeted at the largest factor in total office costs--managerial communications.

Communications Costs

Communications costs represent a growing proportion of all business expense. They may represent 1 percent of sales in manufacturing industries and 12 percent of operating expense in the securities industry, according to Booz-Allen statistics, or as

much as 8 percent of all corporation expense according to a Diebold study, which Dr. James Jewett cites in an Automated Business Communications report.[75] What is more, the rate of increase in communications costs has accelerated within the past few years. Whereas they were showing an annual growth rate of only around 5 percent between 1965 and 1969, the rate exceeded 10 percent during the following five years, and currently are estimated to be growing at a 15 percent annual rate.[76]

Within the Bell System alone, circuit capacity to support increased communications needs has increased from 790 million miles in 1971 to 1.2 billion miles in 1979.[77]

> . . . there is nothing in our experience of recent years to suggest any abatement in the trend of society's demand for communications services.[78] --John D. deButts, Chairman, AT&T

AT&T revenues from long-distance communications (Toll messages and WATS) increased to 18.3 billion dollars in 1978, a $2.4 billion dollar gain, representing more than a 14 percent increase over 1977.[79]

While costs of long-distance message communications have been dropping, in many cases, they have not been falling rapidly enough for the medium-sized or smaller company. As the bill for communications through the established common carriers has risen, the larger company has been able to regain control over these costs by establishing a private network, of which there are in excess of 2500 estimated to be in existence.[80] The cost savings can be dramatic. Hewlett-Packard, for example, can transmit 10 million characters per month from Palo Alto, California, to New York at a cost of 65 dollars using their private network. Internationally,

they can send the same volume of traffic to Geneva at a cost of $1200.[81] The same volume of traffic sent by common carrier would cost 11 thousand dollars to New York and 65 thousand dollars to Geneva, so this large corporation can transmit in volume at less than 1 percent the cost domestically and at less than 2 percent the cost internationally for commercial services.[82] A medium-sized company, unable to afford the capital investment involved in a private network, might resort to leased lines to fulfill similar needs. Though it would not require the same volume as the large company, a comparison of leased line costs for comparable volumes of traffic to New York and Geneva shows figures of $1250 and $13,000 respectively. We can assume then that the medium-sized company will incur per-unit message costs which are higher, by factors of 10 to 19, than those incurred by the larger company. The small company, which cannot even afford the luxury of leased lines, will pay the full commercial rates, at a per-unit cost which is higher by factor of 50 to 100.[83]

One might assume that the larger companies account for a substantial proportion of the total number of business sites in the United States, but this is not the case. Table 1 is adapted from material prepared for a presentation by Joan Ross of International Data Corporation at an Automated Business Communications executive conference in April, 1979.[84]

TABLE 1

U.S. BUSINESS STRUCTURE BY COMPANY SIZE

Company Classification (by Revenues)	No. of Companies	No. of Business Sites
SMALL (less than $10 million)	7,400,000	7,800,000
MEDIUM ($10-$500 million)	68,500	2,055,000
LARGE (more than $500 million)	600	270,000
Total	7,469,100	10,125,000

While the small and medium companies represent more than 97 percent of the total business locations in the United States, solutions to the high cost of long-distance message communications have been exclusively the province of the large company to date. Many small companies already have begun applying modern technology, with dictating equipment, a desk copier and a standalone word-processor or small-business computer being found in the typical "automated" small company.[85] Within medium companies the process is much more advanced, the average "automated" medium business site possessing a minicomputer system, two or three copiers, five or more dictating units, a message terminal, a facsimile unit, and four standalone word processors.[86] The indication from this is that the medium, and even the small, company is prepared to apply high-technology solutions to communications needs, if available. But in the area of long-distance message needs, adequate solutions are

not available. Solutions, in the form of shared networks, may be on the horizon, however.

Travel Costs

> Limitations of natural resources will make it desirable, to an ever increasing extent, to replace the transportation of persons to information by the transmission of the information to the persons. . . .[87] --Joseph A. Bader, AT&T

The rapidly increasing prices for energy have begun to impact an area which is significant in business and governmental expense--travel costs. Just how large this factor has become in government is shown in statistics which reached the U.S. Senate during 1979 indicating that 20,000 federal workers were traveling on official business on any given day. The costs of this travel amounted to more than $3 billion annually.[88] Lawmakers were planning a 10 percent reduction in the appropriations for such travel, a cut of $300 million.

The basic price for oil was $2.80 per barrel of Saudi Arabian light crude in the Fall of 1973. By mid-1979 the same oil was officially priced at $14.54 per barrel, plus surcharges. Spot-market oil, according to some media reports, traded hands at prices well over $30 per barrel. Average U.S. gasoline prices were slightly more than 40 cents per gallon prior to the price escalation, but prices over one dollar per gallon were common in many U.S. areas by mid-1979. For airlines, a one cent per gallon increase in fuel prices translates into 100 million dollars of additional fuel costs annually. With a rise in jet fuel prices similar to that for gasoline, six billion dollars will have been added to the airline fuel bill. As these costs are passed on to the market, it will

become increasingly imperative for businesses to substitute less expensive alternatives such as telecommunications for costly physical visits.

How much of present business travel could be replaced by alternative means is a question of current interest and study. In its proposal to the Federal Communications Commission for an electronic message system (EMS), Xerox cited a Stanford Research Institute study which indicated that 20 percent of all business travel could be eliminated without loss of efficiency if adequate teleconferencing facilities were available.[89] Also cited were actual savings in excess of 20 percent by the National Aeronautics and Space Administration in a pioneering experimental use of video-conferencing facilities. Such a reduction, when applied nationwide to both business and government, would allow concomitant expense reductions in the multibillion dollar range. Nor is this the limit of a reasonable estimate of the possible savings. One need hypothesize only the acceptance of a slight decrease in efficiency in return for still larger reductions in the amount of business travel, for example. And while the travel itself represents a substantial cost, by no means does the cost of an airline ticket measure the total expense of a business trip. Accommodations, dining, and the value of the traveler's time frequently account for larger expenses than the cost of the travel itself. Revenues of the eleven largest airlines are projected by the Value Line Investment Survey to reach 30.3 billion dollars in the 1981-83 period.[90] If 30 percent of these revenues represented business and government travel which could be eliminated, and and if one assumes

an equal savings in food, lodging, and executive time, the total exceeds 18 billion dollars annually for the projected time frame. No knowledgeable observer has yet predicted actual reductions in travel approaching the magnitude cited. However, as energy costs and travel costs continue to increase, the competitive company will have to study the travel/communications tradeoffs and travel/time tradeoffs involved in the way it does business if it is to retain controls on costs and efficiency.

C. Some Barriers

The Analog/Digital Problem

> The modern-day electronic computer is capable of being programmed to furnish a wide variety of services, . . . With its huge capacity and versatility, the computer is capable of providing its services to a multiplicity of users at locations remote to the computer. Effective use of the computer is therefore becoming increasingly dependent upon communication common carrier facilities and services by which the computers and the user are given instantaneous access to each other.[91] --
> Federal Communications Commission

Few readers of contemporary journals concerning data communications, telecommunications in general, or modern computer usage would be surprised to find a statement such as the above as an introduction to a current article discussing communications needs. The statement, however, was made by the FCC in Docket 16979, Regulatory and Policy Problems Presented by the Interdependence of Computer and Communications Services and Facilities, in 1965. The fact that a pressing problem identified more than fifteen years ago remains a pressing problem today gives eloquent testimony to the rapid, wide-spread growth in the use of computers, to the explosive increase in the need for information transfer, and an

inadequate response by the national switched network telephone system to the requirements of data communications, in spite of an awareness of the public networks of the coming needs.

> The telephone network was developed for speech transmission, and its characteristics were designed to fit that objective. Hence, it is recognized that the use of it for a distinctly different purpose, such as data transmission, may impose compromises both in the medium and in the special service contemplated.[92]--
> (Bell System Technical Journal, November 1957)

We tend to sum up the difficulty in using the voice switched network for data communications by saying that it is designed for analog transmission, while data communications utilizes entirely digital methods. While true, this is a bit simplistic since the difference in the characteristics between a transmission system designed to handle analog signals and one meant to transmit digital "bits" results in numerous problems. It may be useful to describe briefly the difference between analog and digital signalling techniques, and then examine some of the more notable deficiencies in attempting to use the voice switched network for data communications. Those interested in a more complete and detailed analysis of the subject are referred to James Martin's excellent text, Telecommunications and the Computer, and to Professor S. W. Maley's chapter on "Telecommunications Systems" in Dr. Leonard Lewin's Telecommunications: An Interdisciplinary Survey, from which much of the following is summarized.

An analog signal may contain an infinite range of amplitude values within a specified length of time, the amplitude values varying as determined by the information source. A digital signal has an amplitude which is representative of the information it is

intended to portray. The amplitude value of the digit "2", for example, might be twice the amplitude value of the digit "1". Typically, only the values "1" and "0" are used, and these binary digits are termed "bits." Such a binary digital transmission system is then simplified to on and off signalling, the presence or absence of an amplitude value. The equipment of the telephone system designed to handle the analog signal, creates problems in digital transmission over the same lines.

Bandwidth. Most of the power in normal speech is within the range from 300 to 3100 Hertz (Hz), and the standard analog channel is designed for a bandwidth of 4000 Hz to accommodate that range and to allow for a small guard band between channels. The square waveshape of the digital signal, on the other hand, requires an infinite bandwidth for perfect reproduction--the basic frequency plus all harmonics. It is not necessary to transmit a perfectly square waveform to produce a usable signal, of course, but the wider the bandwidth the more exact will be the representation of the source information. If a 2000 bit per second (bps) signal is transmitted at 4000 Hz, the pulses will be close enough to the original that good equipment can recover the bits. A 2000 bps data rate, however, is almost impossibly slow for many data uses.

Repeaters. On an analog link the repeaters are designed to re-amplify the received signal. In doing so, both the signal and accompanying noise are amplified. Since the addition of noise is proportional to distance, among other factors, the deterioration of a digital signal on a longer link may be so great that the pulses are indistinguishable. On the other hand, in a link designed

for digital signals, a regenerative repeater is used which recreates the signal pulses, and no deterioration occurs. Few of the circuits in the switched-telephone network are equipped with regenerative repeaters.

Path variations. Because it is a switched network, the nationwide telephone network selects the most convenient routing for each call. The numerous possible paths for a particular call all have variations in characteristics (some of which voice users refer to as a "bad connection"). A digital signal may not withstand the characteristic differences in possible paths, making some unusable.

Echo surpressors. Surpressors used to attenuate the echos caused by impedance changes on voice circuits reverse direction each time the speaker changes, clipping a small part of the first syllable in the process. Especially in full duplex operation, echo surpressors would make data transmission impossible. Consequently, echo surpressors must be disabled whenever a voice circuit is used for data transmission.

Access time. Data transmission typically occurs in bursts, sometimes lasting only a second or two. Access times to dial into the switched network may consume fifteen or twenty seconds. Access time may thus be far greater than transmission time, making the process quite inefficient when the data transmission requirements are for frequent, relatively short-time frames.

Control signals. On the voice communication network, numerous control signals are sent within the channel bandwidth for a variety of purposes--connections, diagnostics, and supervisory

control, for example. The system of control signals was designed without any idea that the same circuits might be used for data transmission. Consequently, if the digital equipment is not specifically designed to avoid simulation of these control signals, it can play pure havoc with the network. The restrictions thus placed on the digital modulation equipment reduce their efficiency and considerably increase their cost.

Bit error rate. Signal quality for an analog signal is measured as a signal to noise ratio. For digital signals the bit error rate (BER) is used. While a poor signal to noise ratio may still provide a usable analog signal, the circuit quality of even the average voice-grade circuit may result in unacceptably high error rates for the digital signal in many applications.

Loading coils. Loading coils are used on analog links to overcome wire capacitance. The use of loading coils reduces signal attenuation over the design range, but sharply attenuates the signal at higher frequencies. Circuits with loading coils restrict data transmission to several hundred bps over a distance of several miles. If the loading coils are removed, data rates of 56,000 (as in AT&T's DDS service) are easily achieved, and 200,000 bps rates, or more, are possible. With regenerative repeaters installed, multimillion bps rates can be obtained. Such unloaded circuits equipped with regenerative repeaters are not generally a part of the voice switched telephone network.

Phase distortion. Some frequency components of any signal are delayed more than others within a wire pair. The delayed components will therefore arrive out-of-phase with the faster components

if correction is not built into the circuit. This frequency-phase distortion is of little consequence on an analog circuit since human understanding of speech is relatively unaffected by it. The same distortion of a digital signal, however, may render the circuit useless; no distinction might be possible between the "one" bit and a "zero" bit. This phase distortion may be corrected by adding capacitance and inductance in such a way that all frequencies are delayed equally. The equipment to accomplish this task is called an equalizer, and building them into a circuit can make very high digital data rates possible. Equalizers are also used to correct for attenuation distortion, the unequal attenuation of the various signal frequencies. Since equalizers are generally unnecessary for analog transmittion, they are not normally a part of the voice-switched network, greatly restricting the use for data transmission.

Modems. Before being sent over a channel intended for voice transmission, the digital signal must be made to conform to the relatively narrow bandwidth available in a process called modulation. At the receiver the signal is demodulated, and the equipment used to accomplish the modulation/demodulation process is called a modem, a contraction of the words describing the process. Modems are expensive and completely unnecessary in a circuit intended only for digital use, and very high data rates can be achieved over a wire pair using a digital baseband signal, without the high expense of the superfluous modems. The modem, in fact, "ultimately will become obsolete."[93]

While this list of the deficiencies of the voice switched network is by no means comprehensive, it should be sufficient to

convey the idea that the use of this network for data transmission can be expensive, inefficient, and frustrating. For that reason, Martin has stated: "Telephone traffic and computer (digital) traffic have characteristics so different that different network architectures are needed."[94]

The lack of adequate (digital) facilities has severely hampered the development of the networks required by business and government. For the military, this lack has resulted in unacceptable alternatives and prolongation of what has long been seen as a critical weakness. Admiral Gravely, Director of the Defense Communications Agency (DCA), in an Air Force Magazine article of July 1979, has explained this difficulty quite well. While DCA had long been aware of the fact that "lack of a widely available, easy-to-use, secure-voice network has been a major weakness in military communications," and plans were developed for "building a digital, secure voice system" for a number of years, the plan failed. The reason was that "the improved secure-voice system called for using digital transmission rates that were too high and thus not suitable for the bulk of today's commercial analog circuits." In the end, Congress "directed that we plan for secure-voice improvements using the analog circuits available today." And the non-availability of adequate digital facilities remains a major weakness in military communications.[95]

A truly advanced integrated-informations system for voice and nonvoice uses will depend ultimately for its attainment on the availability of a network architecture intended for digital use.

Individual networks are being formed and more are proposed, as discussed in the Technology Chapter of this paper. Eventually, experts agree, all transmission, including speech, will be via digital methods. Conversion of the present analog networks, however, is a long-term process which will require more than a decade to complete, and the only satisfactory answer for the present is the development of all-digital networks separate from the public-switched network.

Cost of Alternatives

A major barrier to the replacement of conventional communications systems has been the cost of alternatives. The most cost effective systems in terms of transmission costs are still frequently saddled with labor costs in message preparation which far outweigh transmission considerations,[96] one reason that much effort has gone into word-processing equipment. Replacing conventional mail with alternative forms of nonelectronic mail can be exceedingly expensive. A chart provided by the Business Communications Division of Craftsman Press, for example, shows the total consumer cost for desk-to-desk delivery of a one-ounce typewritten document by various means:[97]

U.S. Postal Service	$ 4.92
Express Mail	12.77
Regular Air Freight	25.77
Network Courier	134.77

Until recently, the costs of electronically transmitted messages were little more advantageous. Kalba Bowen Associates, in a 1978 study prepared for the Federal Communications Commission, used an estimate range of $4.00 to $6.00 as the total cost of a

message using word processors or computer-based systems.[98] These estimates included the costs of preparation, storing, and transmitting the messages.

The Stanford Research Institute, in a 1976 study, used work done by Raymond Panko to arrive at a cost of $1.20 per message for brief messages of about fifty words in length. This figure was an average, based on an analysis of cost data from six message systems studied.[99] A more recent study was provided by William von Meister of Digital Broadcasting Corporation at the Yankee Group's Second Annual Symposium on Electronic Mail in September 1978. The study provides estimates of costs which vary from $5.00 per message for a terminal used to transmit only five messages per day to $1.00 per message if the same terminal is used for fifty messages per day.[100]

Cost such as these have presented a considerable barrier to broad usage of electronic message systems in the past, especially for the smaller user. The larger company, however, has had a wider variety of options. Von Meister provides an example of a complete electronic message system with 100 locations which can achieve a cost per message of $.52, based on a traffic volume of 120,000 messages per month, using Telenet and Tymnet access ports.[101]

For the future, message costs for the large user appear much more optimistic. The Stanford Research Institute used an Arthur D. Little projection of future computer, terminal, and communications costs to arrive at a cost of $.25 per message by 1985.[102] This projection may be still too high for that time frame, since communications costs and computer costs are dropping even more rapidly than expected previously. Especially is this true for satellite

transmission. A wideband channel adequate to transmit a television program coast to coast can currently be leased for $100 per half-hour, compared with a land-line charge of $1,832.00 for the same transmission.[103]

This lower cost for satellite transmission provides an advantage over conventional media that serves as the basis for the proposed intelligent-network offerings of Satellite Business Systems and Xerox's XTEN (See the Chapter on Technology). It is through systems such as these that the cost barriers will really begin to fall. Facsimile transmission, at eight seconds per page, is expected to cost less than fifteen cents, and copy transmitted from a communicating word processor over SBS will be "pennies per page."[104]

The cost barriers will continue to fall for the smaller user as well, since the same transmission cost reductions will apply. To fully take advantage of the promise of the low costs inherent in the high capacity transmission media requires that the smaller user have access to a wide-spread, shared public network similar to that in place for the voice switched network (telephone system). That, in fact, is the idea behind AT&T's proposed "Advanced Communications System" (ACS), discussed later in the paper. Meanwhile, the costly alternatives to conventional methods of information transfer, over long distances especially, will continue to present a continuing, though declining barrier.

Regulation

> Public opinion has turned against certain kinds of government regulation--not the regulations that are supposed to guarantee the safety of nuclear power plants or the efficacy of medicines, but the kind of regulations that shield favored industries from competition.[105]--Common Cause

> The public interest is best served when marketplace forces, rather than government regulation, determine the development, introduction, and availability of technologies and services which use the electromagnetic frequency spectrum. . . .[106]--
> The Communications Act of 1979

Antecedents of Regulation

In its ideals of private enterprise, United States policy had its roots in the doctrine of "*laissez-faire*," which advocated competition, individual initiative, and free trade, separate from state direction.[107] Our Constitution places a special emphasis on the importance of property and individual freedoms in economic matters as the basis of liberty.[108] Abuses by the trusts of the 1880's which interferred with this concept of individual economic freedom and open competition resulted in the formation of the first regulatory commission (The Interstate Commerce Commission) in 1887 and the passage of the Sherman Antitrust Act of 1890.

The mandate for regulation had already been enunciated by the courts in Munn vs. Illinois when Chief Justice Waite found that:

> . . . when private property is affected with a public interest, it ceases to be *juris privati* only. . . . when private property is devoted to a public use, it is subject to public regulation.[109]

Such regulation, as Watkins pointed out in 1940:

> . . . has not aimed at the substitution of government control for competition, but at safeguarding and invigorating competitive forces so that manufacture and commerce may spontaneously regulate themselves in the public interest.[110]

From this we see that the concern of regulatory law was for the public interest, which most have interpreted to include protection for free competition.

Antitrust law aimed at restraint of free trade, especially in the formation of monopolies. The Sherman Act, in Section II, provides that:

> Every person who shall monopolize or attempt to monopolize, or combine or conspire with any other person or persons, to monopolize any part of the trade or commerce among the several states, or with foreign nations, shall be deemed guilty of a misdemeanor.[111]

The Sherman Act was followed by many other acts with similar purpose, including the Federal Trade Commission Act of 1914, the Clayton Act of 1914, The Wheeler-Lea Act of 1938, and the Robinson-Patman Act of 1936.[112] Down to current times the antitrust laws have served an important role in securing the economic freedoms contemplated in the Constitution. As Professor Dudley Pegrum sees it:

> The continuance of a private enterprise system in the United States depends upon our ability to maintain an industrial structure that is primarily competitive in nature. If we are to be successful, the anti-trust laws will have to form the foundation of public policy.[113]

Regulation in Practice

Given a mandate to regulate in the public interest, an interest that is assumed to be furthered best by maximum protection of free and open competition, we would expect to find the regulatory commissions diligent in opposing any trend towards concentration, restriction on entry, limitations on the provision of services, and so forth. The opposite seems to have been the case.

In Senate hearings on "The Establishment of a Commission on Ethics in Government," the response of one commission chairman to a question by Senator Aiken is illustrative of the problem of a commission supporting the industry rather than the public. The senator's question was:

> Is not most of our trouble in the regulatory commissions due to the fact that the members are thrown in a constant association with the people they are supposed to regulate rather than the public, which they are supposed to represent and protect?

The commission chairman's reply was "I thoroughly believe it."[114]

Senator Douglas, at these same hearings, commented to the FCC Chairman:

> I have noticed that the members of regulatory commissions such as the FCC are in a very exposed position if they are militant in defending what they believe to be the public interest. . . . I think certain members of the FCC in the past experienced *that*.

That FCC Chairman's reply was "Do not count me out."[115]

This has been a continuing problem with the regulatory commissions, since they do not deal on a daily basis with the public. Bernstein has found that:

> Forced to reach a working agreement with the regulated parties, a commission develops a passive outlook with respect to the nature of the public interest. It gradually permits the private parties to define the public interest for it.[116]

The problem was noted by Watkins back in 1940 when he attributed to the courts, rather than the Federal Trade Commission, most of the credit for "keeping the fields of industry and trade open to the spontaneous growth of free enterprise."[117]

Weiss has observed that: "Persons who study regulation have repeatedly concluded that commissions see many things from the

point-of-view of the regulated." And he himself finds that: ". . . regulators are courted and pressured by the firms they are supposed to regulate, while the consumer often receives little representation."[118]

Of greater concern, however, is the possibility that a commission would go directly counter to its mandate. More than exhibiting a mere passivity towards the public interest, a commission might so totally take the regulated industry's side that it would restrict the entry of potential competitors, to the public detriment. Weiss has explained how the process may begin with a simple interest in the financial viability of the industry to be regulated, followed by entry restriction, and then elimination of price competition.[119] Once begun, the process is difficult to reverse. Kahn identifies the economic and competitive factors involved:

> So long as regulation imposes restraints on competition, it will have continuously to widen and deepen in scope. The economics of this are quite simple. If regulation limits competition, it must be because some competition would otherwise be feasible.

The eighty-fourth Congress made some interesting conclusions concerning such regulatory restrictions on competition and market entry. A Senate report on "Competition, Regulation, and the Public Interest" prepared by that Congress stated:

> This seems to be the same view of the economy taken by reactionary business and labor unions when they seek to prevent the entry of new enterprises into their respective fields. . . . when such conduct is engaged in by private business or by the labor unions, it is prosecuted as a violation of the anti-trust laws.[121]

The history of regulation in practice has thus not given the Congress reason for great optimism. Established, along with

antitrust law, to protect the public's interest in a society that is as open to free competition and market forces as is possible, the typical regulatory commission ends up being cited by Congress for the abuses it was formed to prevent.

Regulation in Communications

The examples of regulatory commissions which follow the pattern cited by those who have studied them usually brings to mind industries such as the railroads, trucks, and airlines (before they were deregulated). Less often, perhaps, would the Federal Communications come to mind. In spite of a recent record of support for greater competition in the provision of terminal equipment and media services, however, the FCC has provided examples of "typical" regulatory behavior in restricting free entry, and extension of regulatory control.

The FCC has had a more difficult time, perhaps, then those commissions dealing with a more technologically stable industry. Kahn has concluded that the "impact of new technology and the dilemmas it creates for a protectionist regulatory commission are nowhere more clearly illustrated than in the field of communications."[122]

One example is provided by cable TV (CTV). Cable TV began as an industry in the 1950s, serving subscribers by microwave or cable in areas which had limited television availability. The exceptionally high signal quality it provided prompted a move by CTV into the large cities during the 1960s, where the wider range of programs it offered made it a popular service among a broad

range of customers. While the competition with established broadcasters was obvious, the jurisdiction of the commission to protect the existing industry was not. CTV, after all, was not using the frequency spectrum and was asking for none of the TV broadcast channels. Rather, it presented the prospect of plain old free-market competition. The "typical" commission, failing to keep a competitor out of "its" industry could be expected to attempt to extend the regulatory umbrella. True to form, the FCC, in 1966, promulgated general rules asserting its authority over CTV.[123] In an environment more tolerant of competition, the FCC in 1978 eased its restriction by allowing CTV importation of distant signals after simple provision of an analysis showing that the added competition would not hurt local broadcasters.[124] Still, this is something akin to requiring American Motors to demonstrate that it would not injure a local General Motors or Ford dealer before being allowed to sell cars to certain market segments. Regardless, it is difficult to view the FCC reaction to the dynamic new force that CTV represented as being in "the public interest." Rather, the reaction "was clearly affected by the threat that this innovation posed to its own regulatory program, as well as to the survival of the many local stations who hastened to complain about the new competition."[125] Perhaps the most compelling comment on CTV regulation has come from the individual presently in charge of the FCC's Cable Bureau, Mr. Phillip Vermeer, who has been quoted as saying that "the theory of free enterprise raises big questions about the continuing need for the FCC's cable program."[126]

In the interconnect industry, it was the Supreme Court, not the FCC, which opened the market to the competition of private suppliers when it stated in the Hush-A-Phone decision that the prohibition of "foreign attachments" to the telephone network was "an unwarranted interference with the telephone subscriber's right reasonably to use his telephone in ways which are privately beneficial without being publicly detrimental."[127]

To the credit of the FCC, it used the Supreme Court decision in Hush-A-Phone to rule on the Carterfone device in 1968 that:

> . . . a customer desiring to use an interconnecting device to improve the utility to him of both the telephone system and a private radio system should be able to do so, so long as the interconnection does not adversely affect the telephone company's operations or the telephone system's utility for others.[128]

In transmission media, the recent FCC trend has been gradually, but steadily in the direction of more competition. The "Above 890" decision allowed private line operation of point-to-point microwave facilities, "a marked departure from the long-standing policy of permitting only the established carriers to provide such service, and the beginning of the commission's policy to permit more liberal entry into the private line service market."[129] The Specialized Common Carrier decision[130] continued this more liberal policy in an attempt to provide digital communications for computer users who had been hampered by the analog offerings of the established carriers. In this decision the FCC stated "(We) conclude that a general policy in favor of the entry of new carriers in the specialized communications field would serve the public interest, convenience and necessity."[131] The decision provided a refreshing rebuttal to the

more cynical observers of regulatory commissions who have argued that competition, and the public interest, are almost invariably thwarted.

Unfortunately, a more recent decision of the FCC, denying MCI Corporation the right to offer "message toll service" (MTS), which it called "Execunet", was seen as being anticompetitive. The Court, in overturning the FCC decision, in fact, took pains to remind the commission, in strong language, of its obligation to the public interest, stating:

> The ultimate test of industry structure in the communications common carrier field must be the public interest, not the private financial interests of those who have until now enjoyed the fruits of *de facto* monopoly.[132]

The FCC next attempted to deny MCI the right to interconnect the Execunet service to the public network, asserting that it had not yet made an affirmative public interest finding regarding such interconnection.[133] The District Court over-ruled the FCC again,[134] and again the Supreme Court denied review.

According to a 1979 General Accounting Office (GAO) report to Congress, FCC officials feel hampered in their ability to control the industry structure with this decision. They have concluded that the evidentiary burden, regarding entry into the common carrier industry, has been reversed. "Now FCC must show the public interest requires not allowing entry or restricting it in some way."[135] (As opposed to forcing a potential entrant to prove that its entry *is* in the public interest.) If true, this will force the FCC to defend a pro-monopoly decision directly, rather than simply by indicating that a potential competitor has failed

to justify a public interest reason for entry. This should speed up both the FCC decisions on new applications and Court action in striking down FCC rulings which are anticompetitive.

The Communications Act of 1979

The Communications Act of 1979, as seen in the proposed House Bill (HR 3333), is difficult to assess until passage is followed by actions of the new Communications Regulatory Commission (CRC). The language of Title I (Sec. 101) refers to regulation that is necessary "to the extent marketplace forces are deficient"[136]--seemingly a pro-free enterprise policy. Section 411 (1), quoted at the beginning of this chapter, also shows an asserted preference for "marketplace forces, rather than government regulation" to "determine the development, introduction, and availability of technologies and services. . . ."[137] But Title I also refers to telecommunications services "which are universally available at affordable rates," a proviso which could be used by an anticompetitive commission to restrict entry into long-distance communications on the grounds that the loss of revenue to the established (monopoly) carriers would price local service beyond the means of some members of the public.

The intent of the Bill, overall, seems pro-competitive. In a speech at the Communications Networks conference in early 1979, Charles Jackson of the House Communications Subcommittee asserted that the Act "is aimed at returning more of these decisions to the marketplace." He goes on to ask "Who should make the decisions in communications: users and supplers or bureaucrats

in Washington?"[138]

Walter Hinchman, former FCC Common Carrier Bureau chief, countered, at the same conference, that the rewrite was stripping government officials of the power to regulate effectively, and that the powers of the FCC which led to the introduction of competition would be taken away.[139]

Generally, then, the assessment seems to be that the Act, as proposed, is intended to reduce the powers of the Commission to structure the industry. To the extent that the FCC used its former powers to inhibit competition, the new Act would be seen as an improvement in the pro-competitive environment for telecommunications.

Prognosis

The immediate future of telecommunications will offer a wider variety of equipment, services, and networks to the potential user. This assessment is not based solely upon the prospects for passage of the Communications Act of 1979. Without passage, the trend is also towards more competition under the 1934 Act for the following reasons:

a. There appears to be wider support within the FCC for further competition. Those pro-monopoly decisions which have slipped through have caused the authors and backers of the decision considerable embarrassment as the Supreme Court slapped them down (Hush-A-Phone, Execunet). This will allow the supporters of competition at the Commission a more prominent role in decisions.

b. The Congress, in some cases reacting to public opinion and perhaps out of conviction, is more interested in seeing a larger role for competition and a reduction in regulation.

c. Public opinion has turned antibureaucracy, as cited in the Common Cause statement at the beginning of this Chapter, and antiregulation.

d. Competitive forces have become a powerful special interest in their own right. Terminal equipment suppliers and Specialized Common Carriers are far more numerous (as are their customers) than in the past, providing a counter to the single voice of AT&T that prevailed until recently.

e. Technological change in telecommunications is exceptionally dynamic. And, as Alfred Kahn has pointed out, "Pressures for increased competition are especially severe in a technologically dynamic industry."[140] In other words, the pro-monopoly forces stand a fair chance of being steam-rollered if they stand in the doorway to prohibit competitive entries into the telecommunications markets.

f. The policy-making bodies in telecommunications tend to favor competition. The National Telecommunications and Information Agency (NTIA) chief, Henry Geller believes, according to a recent report, that the rewrite of the 1934 Communications Act is the means to deregulation, and the U.S. "cannot have a house that is half regulatory, and half deregulatory," reflecting a general commitment to freer competition on the part of NTIA.[141]

With or without a new Communications Act, the regulatory

barriers, which prevented or slowed the rush to an "information society," will not present the obstacle to telecommunications in the future that they once did.

Financial Considerations

> . . . the one factor that might hold back the growth of telecommunications is scarcity of capital.[142] --James Martin

It is easy to discount Mr. Martin's statement, given the history of financial support in our capital markets for growth industries. One need only compare the price/earnings ratios of companies in the telecommunications industries with the average for all companies to realize the extent to which investors are willing to capitalize the earnings of such firms, and to provide the capital necessary for further growth. Companies such as Rolm, Texas Instruments, Hewlett-Packard, IBM, Storage Technology, Mohawk Data, Digital Equipment Corporation, Data General, and others--all exemplify the support of the capital markets for their shares, in above average price/earnings ratios.

In fact, Mr. Martin's comment probably was not made to indicate that telecommunications will actually suffer from a lack of the capital necessary to further future growth. Rather, he intended to say that the growth of telecommunications is, and will be, so rapid over the coming years that scarcity of capital is the only factor which *could* hold it back.

But there are financial problems in the telecommunications industry--problems which have slowed the development which would have otherwise been possible, and which will be the cause of some concern for the immediate future. The major problem of these is

depreciation rates.

When depreciation rates are considered are problems for telecommunications, it is not the companies already mentioned who are encountering the problem. Rather, it is among the "traditional" telecommunications giants, especially AT&T.

AT&T has an enormous investment in plant, approximately $111 billion at original cost in 1979, which has been only 18 percent depreciated.[143] IBM, largest of the unregulated telecommunications suppliers and a potential competitor, by contrast has written off 53 percent of its total investment.[144] Indeed, if AT&T had used the same depreciation methods as IBM during the 1978 fiscal year, it would have had to report a net loss, instead of a profit exceeding $5 billion, for the period.[145]

The unrealistic depreciation rates for the existing telephone industry arose chiefly from two causes. The first was the simple politics involved in keeping telephone rates as low as possible, which could be achieved to a considerable degree by regulatory commissions simply by denying shorter depreciations lives for plant and equipment. The second reason is that the rapid technological progress in telecommunications was not adequately understood. As a more or less stable, predictable industry, the plant or equipment had an economic life which could be fairly well predicted. The depreciation rates which were established were based upon these predictions of lengthy economic lives.

In today's much more volatile environment, however, the economic life of the equipment is of little significance. Of more importance is the technological life.

The adjustment of the regulatory commissions to the new reality may be difficult, governed as it will be, to some extent, by the politics of increased telephone rates for the consumer. But the process appears to be underway. An article in Telephony entitled "Depreciation Rates Changed, But FCC Pushes Policy Study"[146] reported a modification in allowed depreciation expense which will increase annual cash flow by $63 million for seven Bell companies, four General Telephone and Electronics companies, and a Continental Telephone operating company.

The changes may be coming far too slowly. Lower cost transmission methods, for example, are technologically far more cost effective than the installed plant. The former Chairman of AT&T illustrated this point recently:

> In 1955 the average inventment per circuit-mile of the Bell System's interstate plant was $42; today it's less than $14. We are adding capacity to that plant at a cost of about $2.25 per circuit-mile. And already we are on the verge of commercial introduction of a new generation of transmission systems that will drive costs lower still.[147] --John D. deButts

With competition increasingly growing from alternatives to the system Mr. deButts describes (See the Technology Chapter on Specialized Common Carriers and Intelligent Networks), the depreciation problem could well become acute. Lower rates for long-distance transmission will not allow adequate recovery of the capital invested in existing plant, and replacing it with the newer technologies all at once would require a writeoff of obsolete plant in a magnitude that would be unacceptable to either AT&T or the capital markets.

The barrier to telecommunications growth in past depreciation policies will come from AT&T efforts to delay competition and deregulation, to which the FCC cannot offer an entirely unsympathetic ear, given its role in setting the depreciation schedules in the first place.

The barrier should not be an insurmountable one, however, if the telecommunications market continues the growth which most observers expect. The percentage of the market which will be taken by the alternate carriers may increase, but in absolute terms the coming markets may be able to make use of all the capacity available. If that is true, AT&T may be able to continue deriving sufficient revenues from the obsolete plant to recover its investment and to continue its replacement with the newer technologies. At worst, the financial problems of inadequate depreciation will slow, but not halt, what has been termed the "telecommunications revolution" (by the Executive Vice-President of AT&T)[148] or the "information revolution" (Mr. deButt's description).[149]

Given the importance of the information industries to our growing information society, one would assume that detailed data would be immediately available on the finances of each industry component, including revenues and capital requirements. Such is not the case. The most recent study which provided detailed economic data on the information industries was for the year 1967. Harvard University, in its November 1978 report on "Information Resources: Performance, Profits & Policy," provides the 1967 data, extracted from a Department of Commerce report issued in 1977 entitled "The Information Economy", with the comment that "no more recent estimates

were available as of mid-1978."[150]

Nor does the Federal Government break out communications and information expenses within its budget categories, burying instead such expenditures in more general classifications such as "National Defense" and "Space and Technology," accounting for $105.2 and $4.7 billion, respectively, in the 1978 budget.[151] The Commissioner for Automated Data and Telecommunications Services of the General Services Administration (GSA), Mr. Frank J. Carr, estimates that the civilian agencies of the government are spending approximately $8 billion annually (1979) for data processing and telecommunications.[152] On the military side, the Deputy Assistant Secretary of Defense, Mr. David L. Solomon, estimates that DOD telecommunications and command and control expenditures approximate $4.2 billion (1979).[153] Sources at the National Telecommunications and Information Agency (NTIA) of the Department of Commerce, using a more inclusive definition of telecommunications, estimate total government communications for 1978 at $15 billion.[154]

There are numerous difficulties in estimating the revenues of the information industries or in estimating corporate and business expense for information services. Among these is the difficulty in classifying a service or product. For example, aircraft systems use many components which are electronic, and many, but not all, deal with information transfer. NTIA classifies an electronic system as part of the communications industries if it uses any portion of the electromagnetic spectrum, but here again, it is often difficult to obtain such a breakout of aircraft electronic components. Another difficulty arises in that much of

the desired information is proprietary and not released by the companies involved. Then too, categories overlap all too frequently and it is easy to make the mistake of double counting. Mobile radio equipment and services provide an excellent example of this problem, being included sometimes in radio/TV classifications and also in shipments of the electronic equipment industries. Attempting to determine U.S. expenses for communications by working from industry shipments presents another hazard. Exports are included. And imports can be all too easily excluded. Given all these problems, it is hardly surprising that no authoritative studies to break out or aggregate the revenues of the information industries have been attempted since the 1967 Department of Commerce study.

Still, a rough approximation of the magnitude of expenditures for the broadly classified information industries might be attempted. The approach we have chosen was to start from the known 1967 base, then determine the subsequent growth for a representative sample of the information industries, apply the aggregate growth rate to the 1967 base, and add in the estimated government expenditures. (Government expenditures for information products and services were not included in the 1967 base)

In the following table, representative industries were selected chiefly on the basis of size for inclusion in the sample. Electronic components and accessories were not included because reliable revenue data were not available over a sufficiently long time frame. Industries such as cable television, private information delivery services, and specialized common carriers were not included because, although growing rapidly, they represent a very

small percentage of the information industry, and because their growth from a small base would tend to bias the sample.

TABLE 2

SELECTED INDUSTRY DATA
1970 & 1977

Industry	Revenues (billions) 1970	1977	Growth Rate
Telephone	18.2	40.8	12.2%
Postal Services	6.3	13.0	10.9%
Computer Software/Services	1.6	5.3	18.7%
Computer Systems Mfg.	16.6*	23.8	12.8%
Broadcast TV	2.8	5.9	11.2%
Newspapers/Wire Services	7.0	13.4	9.7%
Schooling	70.1	130.6	9.3%
Research and Development	25.9	42.7	7.4%
Total	148.5	275.5	9.77%

* Data for 1974

SOURCE: "Information Resources: Performance, Profits and Policy," Harvard University, November 1978, p. 7. (Adapted)

Using the results of the table we can begin constructing an estimate of the magnitude of the expenditures for information products and services for 1978 as follows:

TABLE 3

ESTIMATE OF MAGNITUDE OF EXPENDITURES FOR INFORMATION PRODUCTS AND SERVICES - 1978

1967 base: All industry expenditures for information products and services	$214 billion
Aggregate growth rate of 1970-1977 sample	9.77 percent
Extrapolated 1978 expenditures by industry for information products and services using derived growth rate	$597 billion
Government (military and civilan agency) expenditures for information services (NTIA estimate)	$ 15 billion
Total information product and services expenditures for 1978 (estimate)	$612 billion

SOURCE: "Information Resources: Performance, Profits and Policy," Harvard University, November 1978, p. 7. (Adapted)

It might be noted that by this estimate, expenditures for information products and services, broadly classified, accounted for 30.03 percent of the 1978 Gross National Product.

While not entirely satisfactory, based on both samples and estimates, our $612 billion figure at least begins to answer the question of the size of the information industries. The next question concerns capital requirements. Here, better data is available for the industries of interest--the electronics companies, the radio and TV broadcast industry, the telephone companies, and the office and business equipment industry (chiefly computers). The data are not meant to be comprehensive. But, for example, adding 100 companies (from the *Forbes* 500) to the Standard and Poor 400 used in the table, increases the total sales figure only from

$1.216 trillion to $1.6 trillion.[155] Included in the electronic companies are five Standard and Poor categories, including electrical equipment and manufacturers, diversified electronics companies, and semi-conductor manufacturers.

TABLE 4

SELECTED 1978 INDUSTRY DATA

Category	Sales Billions	Net New Long-Term Debt (Millions)	Capital Investment (Millions)
S & P 400	1,216.50	9,845	93,728
Electronics Companies	62.83	--0--*	3,939.3
Office & Business Eqt.	40.6	--0--*	6,356.3
Radio/TV Broadcasting	5.76	118.5	249.2
Telephone	53.8	3,110.0	16,821.0
AT&T	41.0	2,466.4	13,670.0

*Long-Term debt repayments exceeded long-term debt issued

SOURCE: Standard and Poor; AT&T 1978 Annual Report

As was mentioned earlier, the data is not comprehensive. Only thirty-nine electronics companies, ten office and business equipment companies, eight telephone companies, and five radio/TV broadcasting companies are included. Because the largest companies appear, however, the data are representative.

The two major conclusions which may be drawn are, first, that the competitive equipment suppliers appear to be capable of meeting

their capital equipment needs from internally generated funds--in fact, paying off long-term debt may indicate that insufficient new, profitable investments are available to utilize excess funds. Second, it is clear that AT&T is a major factor in the long-term debt market. With 3.37 percent of the S&P 400 revenues, AT&T managed to account for 25 percent of the S&P 400 new long-term debt.

A further conclusion appears warranted from these observations. It appears that, while the competitive industries will be easily able to finance a variety of new telecommunications projects, AT&T will continue to be pressed to meet the capital needs involved in the expansion of its existing services. The deficiency for AT&T is not enormous compared to its revenue base, however (6 percent), and a more liberal allowance in depreciation policies on the part of the regulatory commissions would allow the Bell System to meet its future capital needs without resorting so heavily to the bond market.

CHAPTER II

FOOTNOTES

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CHAPTER III

THE TECHNOLOGY

A. Media

Fiber Optics

> In a little over ten years, optical fiber communication has evolved from a research proposal to a commercial reality. Fiber losses have been reduced from 1 db/meter to 1 db/kilometer in the laboratory, and 5 db/kilometer in cables fabricated under production conditions.[1]

Fiber optics essentially act like wave guides for the light frequencies of 10^{14} to 10^{15} hertz, a range which provides an extremely wide transmission bandwidth. In addition, the small size of one fiber, the allowable small bending radius of the fiber (5 centimeters for a single fiber),[2] immunity to problems such as electro-magnetic interference (EMI), and radio frequency interference (RFI), the flexibility in system growth, the elimination of most ground-loop problems, greater distance spacing between repeaters or terminals, and possible greater economy are some of the features which make optical fiber systems appear much more attractive than copper, or other metalic systems, in many applications.

A dramatic decrease in fiber losses, especially at wavelengths of approximately .82 micrometers, over the past decade has been achieved. In the same period, the reliability of Aluminum-Gallium-Arsenide (ALGaAs) injection lasers, operating continuously

at room temperatures, has been improved dramatically, with the potential for 100 years of continuous service now in grasp. These results are illustrated in Figure 10 (fiber losses) and Figure 11 (injection laser improvements) respectively.[3]

There are three commonly used types of fiber optic cables--the single mode, the multimode step index, and the graded index multimode cable. These are shown in Figure 12.

There are several optic fiber cable designs, depending upon the operational conditions and type of application. For example, the cable might be required to survive the installation and operational stresses of direct burial, aerial suspension, or ducting.[4] Some of the optical fiber cable designs are built in the general arrangement of having multiple fibers with one or more strength members, some filler or cushioning material, and an overall sheath.

The single mode cable gives an inefficient coupling between the light source and the cable due to the small diameter of the core, which is on the order of one wavelength. One advantage of this type, however, is that no dispersion is introduced into the signal propogation. In the multimode step index cable, larger cores are utilized, giving a more efficient coupling between light sources and cable, but with increased dispersion due to the larger path differences between the extremes of the propogating wavelengths. The multimode graded index cable has a lower dispersion effect. This is attributed to the refractive index profile of this mode, which tends to give the same delays to the different wavelength extremes.[5]

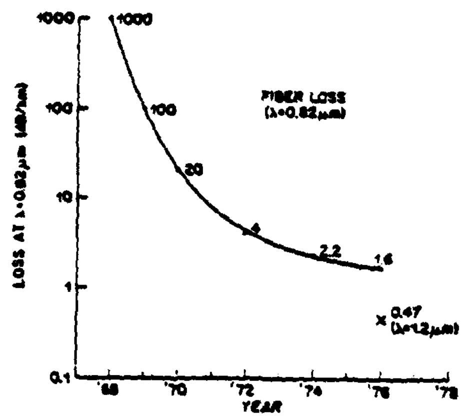

Figure 10. Progress in reduction of transmission loss in official fibers.

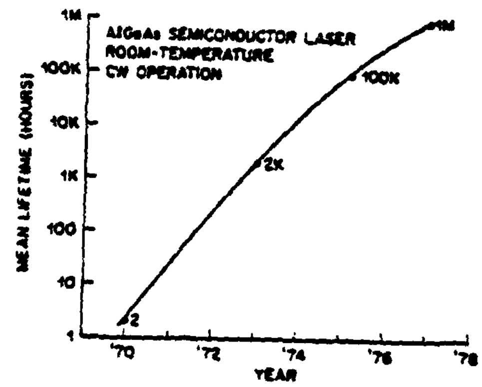

Figure 11. Progress in improvement of reliability of ALGaAs injection lasers.

SOURCE: S. D. Personick and Michael K. Barnoski, "Introduction to Special Issue on Fiber Optics," IEEE Transactions on Communications, July 1978, p.

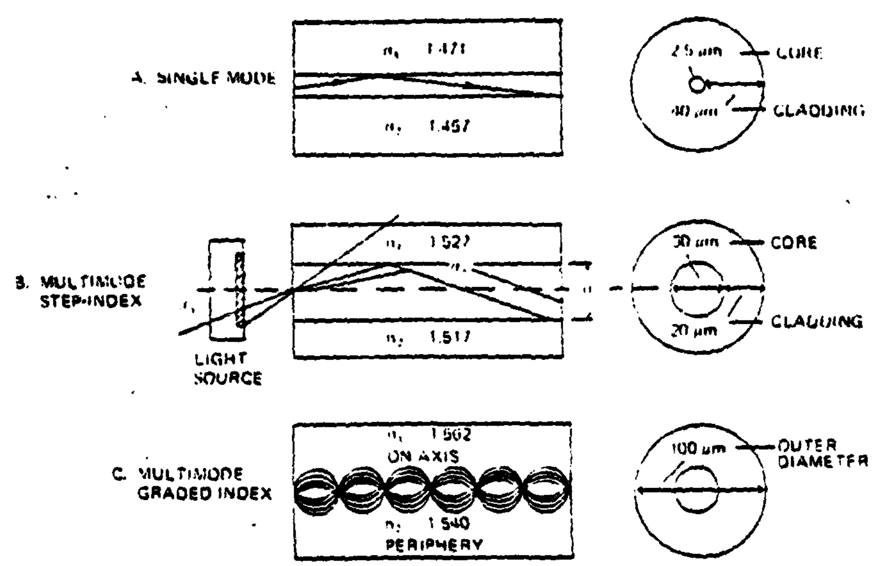

Figure 12. Types of optic fibers

SOURCE: Leang P. Leh, "Fiber Optic Communications Systems," Telecommunications, September 1978, p. 35.

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2 of 3

Fiber optic cables present many advantages compared with conventional metallic cables, such as light weight, freedom from electro-magnetic radiation and similar interference, and the advantages mentioned earlier. These inherent properties of fiber optic cable give rise to unique performance capabilities in specialized installations. Aside from cost advantages, fiber optic cables often prove technically superior to either twisted pair or coaxial cable.[6] A summary of the features and advantages of fiber optic over conventional cables is presented in Table 5.

TABLE 5

OPTICAL FIBER VS. CONVENTIONAL CABLE SYSTEMS
FEATURES AND ADVANTAGES

Feature	Advantage
Large Bandwidth	Low cost per channel. Expansion capability. Increased data carrying capacity.
Immunity to interference and radiation.	Reliability, less crosstalk, security.
Dielectric	Electrical isolation. Elimination of ground loops.
Low loss	Improved signal attenuation
Resistance to tapes, small size, low weight.	System security. Space and weight savings. Ease of installation.
Rugged, durable, long life	Enhanced environmental performance

SOURCE: Richard C. McCaskill, "Fiber Optics: The Connection of the Future," Data Communications, January 1979, p. 68.

A distinct feature of fiber optic systems is the possible use of much longer repeater spacing, thus reducing substantially the number of repeaters required for the same route.[7] Examples of fiber systems using a laser as the light source, as compared with conventional metallic cable systems, are presented in Table 6.

Another striking feature of fiber optic over metallic cables is their flat loss curve; signal attenuation in a fiber-optic waveguide is relatively independent of frequency. Signal attenuation in coaxial cable, even for the highest grade, increases rapidly with frequency. By contrast, attenuation in the optical waveguide is flat over a range extending to more than 1 GHz.[8] A comparison of the two is presented in Figure 13, demonstrating the expansibility of a fiber optic data link versus its metallic counterparts.

Cost estimates for fiber optic cables, installation and jointing, and repeaters, will vary according to the type of fiber and the kind of application. Attempts have been made to compare a copper cable system to an equivalent optic fiber system, based on a route of 50 to 100 Kilometers. The costs compared include the cable and installation, repeaters and housings, and housing provisions. The multiplex equipment, which is common to both systems, was excluded from the study.[9] Figure 14 illustrates the comparative costs, for data rates in the range of 2 to 560 Mbps, on a "per-voice-circuit-kilometer" basis. It is evident that fiber optic systems become more economic compared with conventional cables at higher capacities. For example, at 560 Mbps, the equivalent of 7680 voice channels, the relative cost per circuit is 1.7 for the optical fiber system, while it is 5.2 for the copper system. At very low

TABLE 6

COMPARISON OF METALLIC WITH POSSIBLE FIBER OPTIC CABLE SYSTEMS

System Capacity		Metallic Cable Systems		Fiber Optic Systems	
Mbps	Voice Channels	Cable Type	Repeater Spacing (Km)	Fiber Type	Repeater Spacing (Km)
2.048	30	Voice Frequency	2	Step Index	12 - 16
8.448	120	0.6 - 0.9 Screened Pair	3 - 4	Graded Index	10 - 12
34.304	480	2.8 mm Coax	2	Graded Index	10 - 12
140	1920	4.4 mm Coax	2	Mono-Graded Graded Index	8 - 10
560	7680	9.5 mm Coax 4.4 mm Coax	1.6 - 2 1	Mono-mode	5 - 6

SOURCE: Leang P. Yeh, "Fiber Optic Communications System," Telecommunications, September 1978, p. 38.

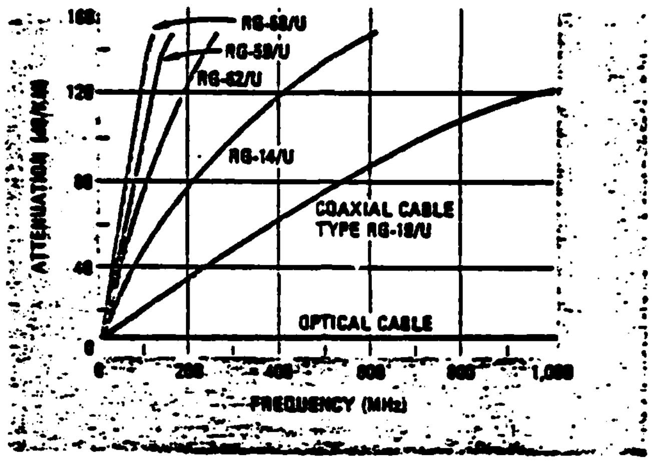


Figure 13. Signal attenuation in optic fibers versus different metallic cables.

SOURCE: Richard C. McCaskill, "Fiber Optics: The Connection of the Future," Data Communications, January 1979, p. 68.

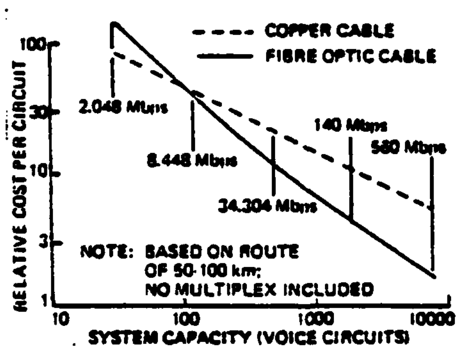


Figure 14. Approximate capital-cost-per-circuit relationship for a range of fiber-optic.

SOURCE: Leang P. Yeh, "Fiber Optic Communications System" Telecommunications, September 1978, p. 38.

capacities, 8.448 Mbps and lower, for example, it appears that fiber optics cannot presently compete with simple paired cable systems, although special applications, such as in crowded city cable ducts, might warrant their use in spite of the cost differential.

Optic Fiber Applications and Examples

The optical fiber is a very versatile transmission medium, as was demonstrated earlier. When suitably engineered, optical-fiber cables may be used in a variety of applications where twisted copper wire pairs, coaxial cables, and even metallic waveguides are now used for transmission of information. Because of its remarkable advantages, optical-fiber cable transmission systems are expected to be applied in many fields, as categorized in Figure 15.

The major field applications in telecommunications networks broadly consist of:

1. Intercity and interoffice trunk lines
2. Intra-office and subscriber premises transmission lines
3. Subscriber loops
4. Submarine lines
5. Television transmission lines, such as CATV.[10]

In the category of "data bus, data link," there are a variety of computer-systems applications where fiber optics are cost effective and where their performance features and technology are well-matched to computer-design requirements. The optic-fiber cable may be used to provide direct links between two or more computer systems in offices and factories. Its use in the interconnection and networking of microcomputers and minicomputers helps achieve new distributed processing architectures. These optic-data links permit

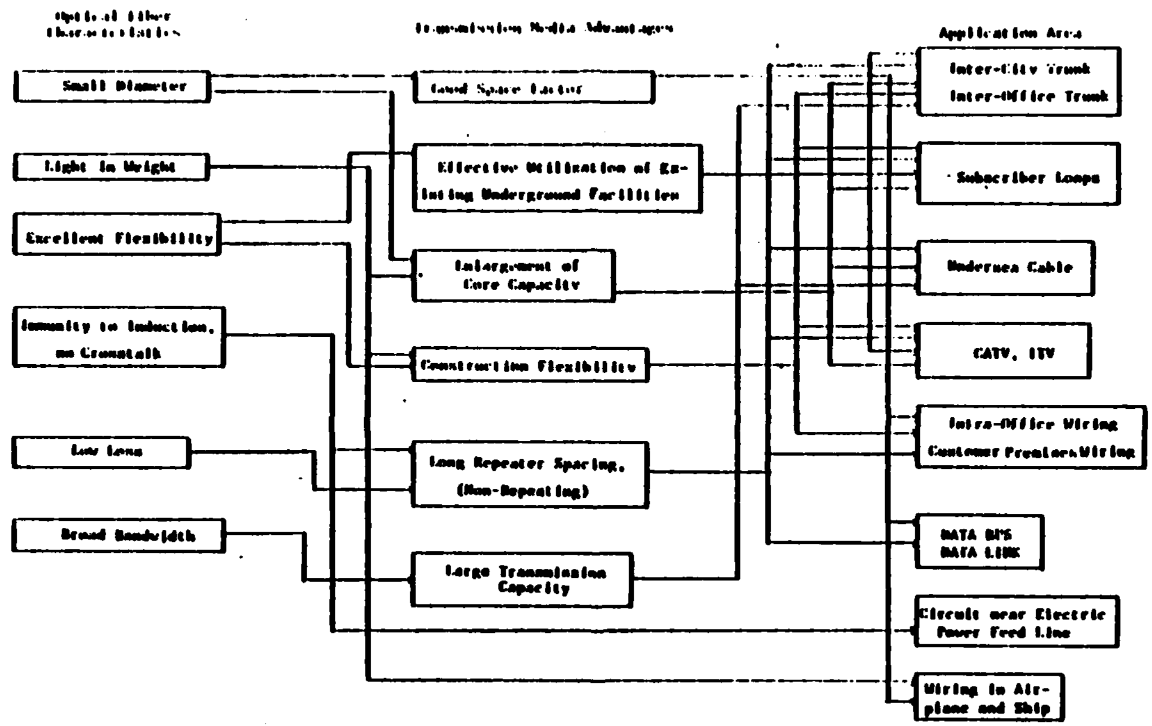


Figure 15. Optic fiber transmission application area.

SOURCE: Kunio Okura and Musayoshi Esiri, "Opitical Fiber System Application Aspects in Future NTT Networks," <u>IEEE Transactions on Communications</u>, July 1973, 969.

faster data flow between central processors, while ensuring uninterrupted transmission, regardless of electrical or other interference. They can also be used effectively to link the computer with its display terminals. Many of these terminals are installed in carpeted offices where the connection is often subject to static electricity problems. Fiber-optic cable eliminates these problems, allowing the systems designer to increase data rates while still retaining the use of thinner cable for easy installation under carpets, around baseboards, and through ducting. The greater security from intercept, a factor for those concerned about the possibility of eavesdropping, enhances the fiber-optic potential for some applications.

In computer systems applications, fiber optic cables connect a variety of peripheral devices to central processors. The large bandwidth provided by the fiber optic cable permits high rates of serial data transmission between the central processor and disc drives, printers, and optical scanners. In these applications, fiber optic connections provide significant size reductions compared to connectors for copper conductors. They actually require less than one-quarter the physical space.[11]

Optic-fiber cables are also well-matched to system design requirements for telephone systems, due to their large bandwidth. They are used in telephone transmission applications, satellite and microwave entrance links, and in distribution networks, particularly where telephony and broadband services can be integrated. Optic-fiber telephone cables have proved to have excellent tensile strength and crush-resistance (maximum compressive force

equal to 2.4 tons per meter with a permissible maximum tensile load of 400 kilograms).[12]

Trunk transmission lines represent another telephone systems application for fiber optics. The smaller physical size of fiber-optic cable permits increased data capacity to be installed in existing interoffice trunking ducts of telephone companies or other large corporations. Intercity trunks also benefit from high-capacity fiber-optic systems.

Airfield communications is another aspect of field applications for fiber optics. In this area, cables are typically housed within the same ducts as other electrical and radio cables where they are subject to a hostile environment of electromagnetic and radio interference. Conventional copper conductors should be shielded, but shielding brings an increase in the size of the cable without curing the problem of "noise." Fiber-optic systems improve the quality of airfield communications and ease the problem of future expansion. The systems are dielectric and provide complete immunity to noise. Here again, as in other applications, the reduced size of the cable permits additional information-carrying capacity within present ducting.

National defense applications include aerospace, naval, and military communications. In avionic systems, fiber-optic cables for data transmission can produce significant reductions in operating costs, since these cables can contribute a weight reduction factor of 10:1 over copper conductors. During the life of an aircraft, operating costs can be reduced by approximately a thousand dollars for every pound eliminated from the aircraft

weight. Again, the immunity from electromagnetic and radio frequency interference insures "clean" data transmission. In naval communications, this feature is equally important. "The modern warship is a computer-controlled, floating electronic arsenal," according to one account, "designed for immediate action. The environment for data transfer from computer to peripherals is extremely hostile, but the need for clear, undistorted, high-speed data transmission is paramount." Fiber optics satisfy that requirement technically and cost-effectively.[13]

Field communications demand a transmission medium which is light, rugged, reliable, secure, and immune to interference. In meeting all of these requirements, fiber optic cable is superior to copper conductors. The reduced physical size adds to cost savings as well as improved mobility for portable weapons systems. Cables that previously filled 4 one-ton trucks can now be carried in a single truck. The integral strength members within fiber-optic cable provide substantial crush resistance. Laid across roads, the cable will withstand the punishment of military traffic over it. From a security-of-traffic viewpoint, optic-fiber cables do not radiate, nor can they be easily tapped or jammed. Table 7 summarizes some of the key fiber-optic capabilities which have been achieved and their potential impact on military systems. There do remain, however, several problem areas which need to be addressed before fiber-optic systems can be widely placed in field use. These problems, listed in Table 8 are currently receiving attention in Army-sponsored fiber-optic applications research. It is anticipated that the problem areas will be resolved in the early 1980s.[14]

TABLE 7

RECENT DEVELOPMENTS OF FIBER OPTICS AND THEIR IMPACT ON MILITARY SYSTEMS

Technical Development	Military Impact
1) Achieved 500 KPSI, 5% elongation fiber[1] capable of passing proof tests in 1 km lengths with virtually zero breakage	1a) Assured survivability of single fiber strand payed out of a container at speeds up to 600 ft/sec
	1b) Opens possibility of single fiber cable inexpensive enough to be field throw away item
	1c) Reduction in weight, size, and cost of cables since less protective material is required
2) Development of sources in the 1-1.7 μm spectral range	2a) Operation in the lower attenuation region of the spectrum may eliminate need for repeaters in Army tactical long lines
	2b) Effects of gamma and neutron radiation on fiber cables is diminished in the 1.-1.7 μm range
	2c) Simplifies the development of single fiber bi-directional communication systems. Reduces the required number of fibers by a factor two for Army links

TABLE 8

FIBER OPTICS PROBLEM AREA

Problem Area	Current Status	Goal
1) Field Connector	1) Single element 2 dB loss-not full military specification	1) Multi-element, 1 dB ± 0.3 dB, military specifications item
2) Nuclear Effects	2) Steady state losses acceptable, transient losses not well defined	2) Fully survivable fiber cable in nuclear environment
3) Sources	3) Satisfactory MTBF (10^4 +) at room temperature	3) MTBF 10^4 + over full mil spec temperature range
4) Fiber Cable Survivability	4) Factory tested, however little tactical field test data	4) Fully tested cable
5) Bi-directional Coupler	5) Exploratory development	5) Bi-directional single fiber links having a range of 8 km
6) Field repair	6) Not yet achieved	6) Full repair capability, with limited lower level maintenance
7) Repeater power consumptions[2]	7) 800 mw for full duplex repeater	7) 250 mw for full duplex repeater

SOURCE: Larry Dworkin and J. Robert Christian, "Army Fiber Optic Program: An Update," IEEE Transactions on Communications, July 1978, p. 1000.

One example of Army application of fiber-optic cable was recently provided by IEEE members Larry Dworking and Robert Christian.[15] CX-11230 twin coaxial cable has been used to provide long-haul, time-division multiplexed multichannel field transmission. Fiber-optic cable can be substituted for the CX-11230 using graded-index fibers to allow for 8 kilometer unrepeatered lengths at data rates up to 20 Mbps. A longer version of 64 kilometers, however, does require repeaters in providing a data rate of 2.304 Mbps. Table 9, which compares the two cable systems illustrates that the optical-cable system is more economical in

TABLE 9

COMPARISON OF EQUIVALENT TRANSMISSION LINKS
(Cable versus Fiber Optic)

	CX-4566 Link	Fiber Optic Link
Cable Weight	138 kg	8 kg
Cable Cost (est.)	\$2300.00	\$ 300.00
Cable Volume	$0.2m^3$	$.02m^3$
Terminal Cost (est.)	\$ 300.00	\$2600.00
Terminal Weight	9 kg	18 kg
Power Consumption	Common battery	26 W

SOURCE: Larry Dworkin and J. Robert Christian, "Army Fiber Optic Program: An Update," IEEE Transactions on Communications, July 1978, p. 1001

these applications, even at data rates below the 8.448 Mbps breakeven point which was found in Figure 14. The Army has great expectations for fiber-optic applications where electromagnetic interference, radio frequency interference and crosstalk immunity; reduced deployment weight and volume; and freedom from electromagnetic pulse effects are important considerations. The cost effectiveness of fiber in many applications is an added bonus.

The promise of fiber-optic systems for high density, short-haul telephone systems is illustrated by an operating system, in use since July 1978, within the Vista Florida Telephone System. This system transmits the third-level signal of the North American digital hierarchy (44.736 Mbps; see Table 10). The capacity of the system is 672 channels of standard voice circuits or equivalent, such as data signals or band compressed video signals, over a pair of optic fibers. For this system a binary signal is used and a parity check method is employed to monitor transmission performance. To interleave the parity pulse with the main pulse stream, the line-bit rate is slightly increased from the original rate of 44.736 Mbps.[16] These and other main parameters of the fiber-optic cable transmission system are listed in Table 11.

The maximum allowable line loss (MALL) was calculated to determine repeater requirements. MALL is equal to the receiver sensitivity minus the output peak level. These data are available in Table 11 (-51 dBm and -3 dBm, respectively). The MALL would therefore be 48 dBm (-51 dBm minus a -3 dBm). However, the effects of aging, additional splices after original installation, connector loss in equipment, and so forth, are taken into consideration.

TABLE 10

NORTH AMERICAN DIGITAL HIERARCHY

System	Rate (Mb/s)	Duplex VF Channels	Repeater Spacing Miles, (km)	
T1	1.5	24	5.5	(8.9)
T2	6.3	96	5	(8)
T3	44.7	672	4	(6.4)
T4	274.0	4032	2	(3.2)

SOURCE: International Telecommunications Exposition, Exposition Proceedings (Dallas, Texas: Horizon House, February 26 - March 2, 1979), p. 150.

TABLE 11

FIBER OPTIC SYSTEM MAIN PARAMETERS

Bit rate	44.736 Mb/s
Line bit rate	45.091 Mb/s
Light source	BaALAs Laser diode
Light detector	Si APD
Line code	Scrambled binary (50% duty)
Output level	
Peak power	3dBm
Average power	-3dBm(mark density 50%)
Receiver sensitivity (pe=10)	-51dBm(average power)
Overhead bit	parity check, SW control, orderwire
Regenerator (one way)	
Dimensions	95x230x53 mm
Power consumption	2.6w (12v, 220mA)

SOURCE: International Telecommunications Exposition, Exposition Proceedings (Dallas, Texas: Horizon House, February 26 - March 2, 1979), p. 137.

Assuming a maximum of 9 dB from the total of these factors, the MALL becomes 39 dB.

The cable used had a loss of 6 dB/kilometer, including splice loss, so repeater spacing could be determined by dividing the MALL by the loss per kilometer (39 dB divided by 6 dB) to arrive at a minimum spacing of 6.5 kilometers. Since the installation covered a distance of 8.7 kilometers, a single intermediate repeater was used.

Bit error rate measurements were recorded for a 5 kilometer, and the results were plotted (See Figure 16). The results show that the system is operating with about a 3.5 dB margin, the difference between the fiber-output level (-42.7 dB) and the equipment sensitivity (-51.2 dB) at a bit error rate of 10^{-10}. [17]

This example provides an indication of the possibilities for substituting fiber-optic cable for conventional cable where the extremely high capacity in a very thin cable would be advantageous, as within the crowded cable ducts of metropolitan areas.

And what of the future? According to Mr. John R. Pierce, former Executive Director, Research Communications Sciences Division, Bell Laboratories, and instrumental in the Echo and Telstar satellites, "In the long-run satellites cannot compete with fibers for carrying digital traffic between large cities in the United States or between the U.S. and Europe."[18] As for homes and offices, Mr. Pierce asserts, "Be sure of one thing. We *will* have full duplex to homes and offices eventually, at 64 kbits/s and ultimately, via fibers, at many Megabits/second."[19] One could sum up by concluding that, except for special applications, the future belongs

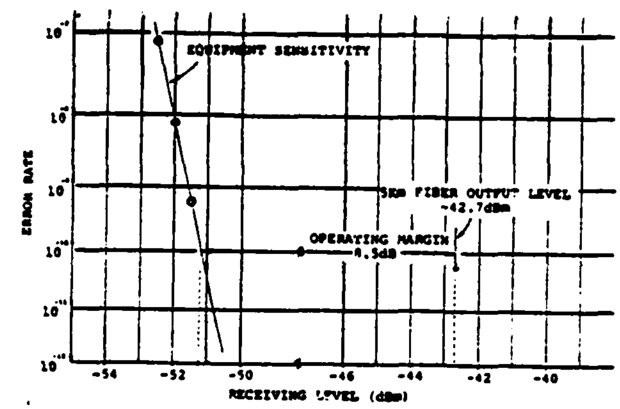


Figure 16. Error rate performance

to fiber optics.

Satellites

> We now know how to build satellites with enough capacity to provide every man, woman, and child with a computer terminal if that were a desirable objective.[20]--James Martin

The wildest dreams of twenty years ago, and the most optimistic predictions of ten years ago have been overtaken by a reality that exceeds both as technological developments in satellite communications have spurred a rate of growth that justifies the commonly used expression "explosive."[21]

While the number of satellites and the number of associated earth stations estimated to be put into use may not provide a complete picture, since individual satellite capacities are increasing so rapidly, a projection is still useful in helping to visualize some aspects of the growth in satellite communications. Mr. Wilbur Pritchard of Satellite Systems Engineering Incorporated has made projections for a ten-year period, short enough so that they can be arrived at by reasonable extrapolations of existing programs and plans, and at the same time long enough so that the vagaries of bureaucracies and the caprice of technical difficulty will average out. The results he arrived at are summarized in Tables 12 and 13. The original predictions for satellites were based on a detailed analysis of more than thirty different systems.[22]

As the numbers of satellites and earth stations grow, the associated technology and techniques, which will be examined in this section, have been growing apace, providing the capacity for the applications, some only dreams themselves, which lie ahead.

TABLE 12

PROJECTED SATELLITE LAUNCHES

Year	Number of Satellites	Cost ($)
1978	11	$ 240 million
1979	26	870 million
1980	15	340 million
1981	14	320 million
1982	9	330 million
1983-88	69	2,350 million
Total	144	$4,450 million

TABLE 13

PROJECTED EARTH STATION INSTALLATIONS

Year	Number of Terminals	Cost ($)
1978	1200	$ 315 million
1979	1600	410 million
1980	2200	465 million
1981	2700	500 million
1982	3300	590 million
1983-88	15,000	3,200 million
Total	26,000	$5,480 million

SOURCE: Wilbur R. Pritchard, "Is Satellite Communications a Viable Market?" Telecommunications, March 1978, pp. 14-22.

The interest and imagination of people, businesses, and governments around the globe have been captured because, through satellite communications, virtually the entire world can be interconnected by networks capable of providing economical, reliable transmission of voice, teletype, data and video signals.[23] The demand for satellite services has been growing even faster than the previously expected rate. RCA Americom, for example, moved up its launch of Satcom III to December, 1979, a year earlier than planned, and transferred its reservation on the Space Shuttle, intended for Satcom III, to a Satcom IV satellite.[24] Western Union is also moving ahead with plans for a third Westar as well as the launch of the first of four Tracking and Data Relay Satellites in a ten-year contract with NASA.[25] Western Union cited the increase in occasional use program distribution from 300 hours in 1975 to ten thousand hours in 1978, and a growing number of inquiries for future service, among the reasons for proceeding with launch of the third Westar.[26] These inquiries were related to all areas of satellite communications, including audio, video, data, and facsimile, one indication of the breadth of the demand. Television broadcast is another area of certain growth in demand for services. All three networks are reported to be examining the use of satellites in transmission of prime time programming to affiliates, following the earlier lead of the cable TV broadcasters.[27]

Communications Satellites

A communications satellite is, in essence, a microwave relay in the sky. It receives microwave signals in a given frequency band

and returns them to another point on earth in a frequency band separated from the first. A different frequency for the retransmission is necessary because otherwise the powerful transmitted signal would interfere with the weak incoming signal.

A satellite may be characterized by the number of transponders it carries. The transponder consists of the equipment which receives a signal, amplifies it, changes its frequency, and retransmits it to another satellite or to an earth station terminal.[28] Most satellites now have more than one transponder, each of which typically handles a bandwidth of approximately 36 Megahertz, although this has differed from satellite to satellite. A bandwidth of 36 Mhz may be used to carry any of the following:

1. One color TV channel with program audio.
2. 1200 voice channels
3. A data rate of fifty Mbps.

The center of 24 Mhz of each band may relay:

1. 16 channels of 1.544 Mbps data.
2. 400 channels of 64,000 bps.
3. 600 channels of 40,000 bps.

Contemporary transponders carry a large number of voice channels on one or more carriers to one or more locations or, alternatively, the wideband signals of television or data at rates of 120 Mbps.[29]

Satellite Earth Stations

Basically, an earth station consists of a large dish antenna which is directed at the satellite in much the same way that an earthbound microwave relay dish is aimed at the next tower in

the chain. The first earth stations constructed were massive and had quite large diameters to recover the relatively weak signals being relayed from the satellite. Today's earth stations, in some applications, are small enough to be erected quickly in a parking lot behind an office building or factory.

In order to standardize the performance criteria of earth stations, the FCC has established specific requirements for satellite earth stations employing small antennas in its Declaratory Ruling and Order RM 2725, FCC 76-1169. The two most important performance criteria are the antenna gain and the secondary pattern characteristics. The gain, along with the guidelines of other system parameters, must provide carrier--to-- noise margins which are at least 3.65 dB above the receive system noise threshold.[30] This level is sufficient to insure that satellite link degradations will not drop the receiver level below the minimum threshold for reception. The site location, the satellite "effective isotropic radiated power (EIRP), elevation angle, and the receive system components, in addition to the antenna gain, serve to establish the receive carrier-to-noise level for a given system. The carrier-to-noise ratio $(C/N)_{dB}$ for satellites is given by the following general formula for either the uplink or down-link:

$$C/N = G/T_{sys} - L_{fs} + EIRP_{dBw} - K - B$$

where:

EIRP is effective Isotropic radiated power of the two antennas in the link

G/T_{sys} is the gain to system noise temperature ratio, in dB, of the receiving antenna.

L_{fs} is the free space path loss, in dB

K is Boltzman's constant, in dB

B is the system bandwidth, in dB

For the earth to satellite path (uplink), the EIRP for the Intelsat systems may be as high as 95 dBw based on an actual power of 33 dBw and an antenna gain of 62 dB. The path loss, L_{fs}, is about 200 dB, and the G/T_{sys} ratio for the satellite receiving system is about -18 dB. Thus: $C/T_{sys} = 95 - 200 - 18 - (-229) - 87 = -19$ dB where -229 is 10 log K and 87 is 10 log B.[31]

For the satellite-to-earth path, two global-coverage antennas, having beamwidths of 17 degrees, and two spot-coverage antennas having beam widths of 4.5 degrees, are available. For the global antennas, the EIRP is 22 dBw, and for the spot antennas, the EIRP is 33.7 dBw, the latter based on a gain of 31.7 dB. The path loss is about 197 dB and the G/T_{sys} ratio is 40.7 dB. (This figure is based on the use of a 29.5 meter antenna having an efficiency factor of 70 percent and a T_{sys} of 78 degrees Kelvin.) The gain of the receiving antenna is 57.7 dB, using the same relationship as that above. For the case of the spot antenna:

$$C/N = 33.7 - 196.9 + 40.7 - (-229) - 87 = 19 \text{ dB}$$

The C/N value in both cases is about the same.[32]

For today's typical small earth stations, with a 5-meter diameter, a 44.5 dB gain and a G/K_{sys} equal to 22.9 dB/K for downlink and - 2.2 dB/K for uplink, the C/N calculation for an uplink with a 39 MHz bandwidth would be as follows:

L_{fs} = 202.2 dB (measured)

B = 75.9 dB (designed)

K = 228.6 dBw/K (constant)

EIRP = 84.2 dBw (assumed for this example)

C/N = - 2.2 - 203.2 + 84.2 - (-228.6) - 75.9 = 31.5dB

For the downlink:

L_{fs} - 199.1

EIRP - 34.4 dB/K with B and K as above

C/N = 22.9 - 119.1 + 34.4 - (-228.6) - 75.9 = .9 dB .[33]

The small antenna secondary pattern characteristics play a vital role in frequency coordinating the selected earth station site. The very congested frequency spectrum in the 4/6 Ghz band from terrestrial microwave systems makes coordination sometimes difficult. In addition, the antenna pattern is a key factor in interference protection from adjacent satellites. The FCC, in its declaratory ruling, defined pattern requirements for the small earth station antenna. These pattern requirements are plotted in Figure 17.

A complete tabulation of the typical small earth station antenna requirements is shown in Table 14.

Satellite Orbits

Modern communications satellites have orbits very different from their experimental predecessors, such as the AT&T Telstar satellites and RCA's Relay satellite. The latter traveled rapidly around the earth at a relatively low height. The Telstars had highly elliptical orbits. All of today's communications satellites, outside those of the Communist block, appear to hang stationary over a single point on earth. Their orbit is over the equator and each travels in the same direction as the earth's surface in its

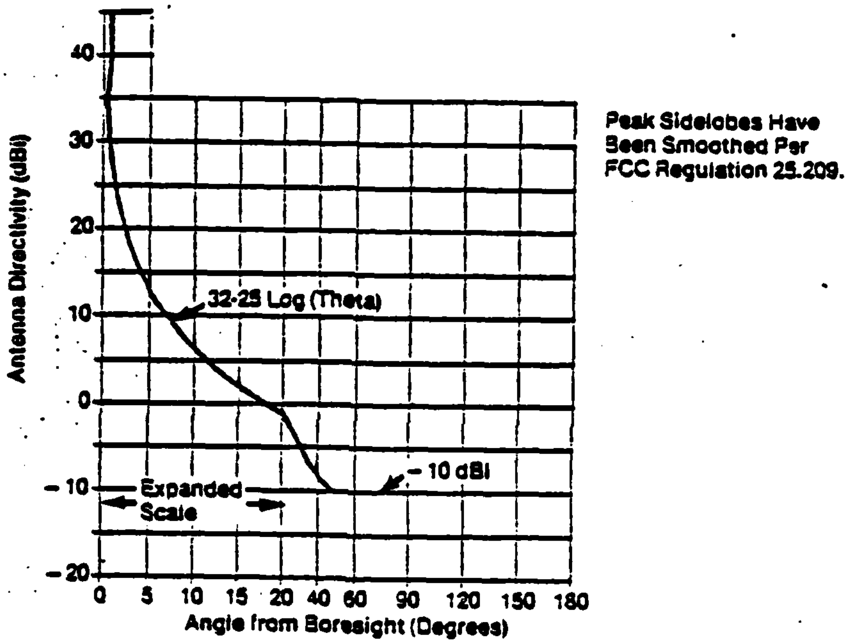


Figure 17. Small earth station antenna radiation distribution envelope.

SOURCE: Marvin D. Shoemake, "The Small Antenna For Satellite Communications," Satellite Communications, February 1979, p. 24-25.

TABLE 14

TYPICAL SMALL EARTH STATION ANTENNA REQUIREMENTS

ELECTRICAL CHARACTERISTICS
Operating Frequency Range
Transmit
5.925 to 6.425 GHz
Receive
3.70 to 4.20 GHz
Antenna Gain
44.5 dBi @ 4 GHz
Half-Power Beamwidth
Transmit
0.85°
Receive
0.9°
15 dB Beamwidth
Transmit
1.25°
Receive
2.0°
VSWR
1.3:1
Polarization
Linear
Polarization Adjustment
360° continuous

Isolation (Receive-to-Receive) Dual-Pol
30 dB minimum
First Side Lobe
−13 dB
Noise Temperature @ 30° Elevation
20°K
MECHANICAL CHARACTERISTICS
Antenna Size
5 Meter Diameter
Mount Type
Elevation-over-Azimuth
Reflector Surface Tolerance
Antenna Pointing Range
Azimuth 110° (2 overlapping sectors)
Elevation + 15 to +60° continuous
Pointing Accuracy
0.03° rms in 20 mi/h winds gusting to 45 mi/h
0.11° rms in 60 mi/h winds gusting to 85 mi/h
Survival Wind Loads
125 mph in any pointing direction
No stowing required 87 mph with 2" radial ice
Operational Temperature Range
−35 to +140°F

Total Weight (Reflector and Mount)
1500 lbm

SOURCE: Marvin D. Shoemake, "The Small Antenna For Satellite Communications," Satellite Communications, February 1979, pp. 24-25.

rotation. It takes exactly 24 hours for the satellite to complete one revolution, exactly matching the earth's rotation. Such an orbit is called a geosynchronous orbit. Figure 18 shows different satellite orbits, and Figure 19 plots the time a satellite takes to travel around the earth versus its height, illustrating the point at which a satellite reaches the geosynchronous orbit.

The spacing of satellites in orbit cannot be too close or the uplink microwave beams for adjacent satellite will interfere with one another. Five degree spacing between satellites had been the accepted practice for the 4/6 GHz band satellites, although later launches are providing for a 4 degree spacing, and three may be feasible. Spacing requirements limit the number of "slots" for geostationary satellite service to the western hemisphere to about 15 or 16. Prime slots for covering the entire fifty states number approximately six. However, at the higher broadcast frequency bands (10/14 and 18/30 GHz), transmission beams narrow, and satellites could be placed in orbit about one degree apart. This could effectively quadruple the number of total slots available for service to the western hemisphere, as well as the number of prime slots for a fifty-state coverage.

Satellite Transmission

Present commercial satellites generally use the 4/6 GHz band--the first number referring to the downlink band and the second to the uplink. These are the main frequencies used by the terrestrial microwave common carriers, using bandwidths of 500 MHz. Figure 20 shows the frequencies allocated to satellite use.

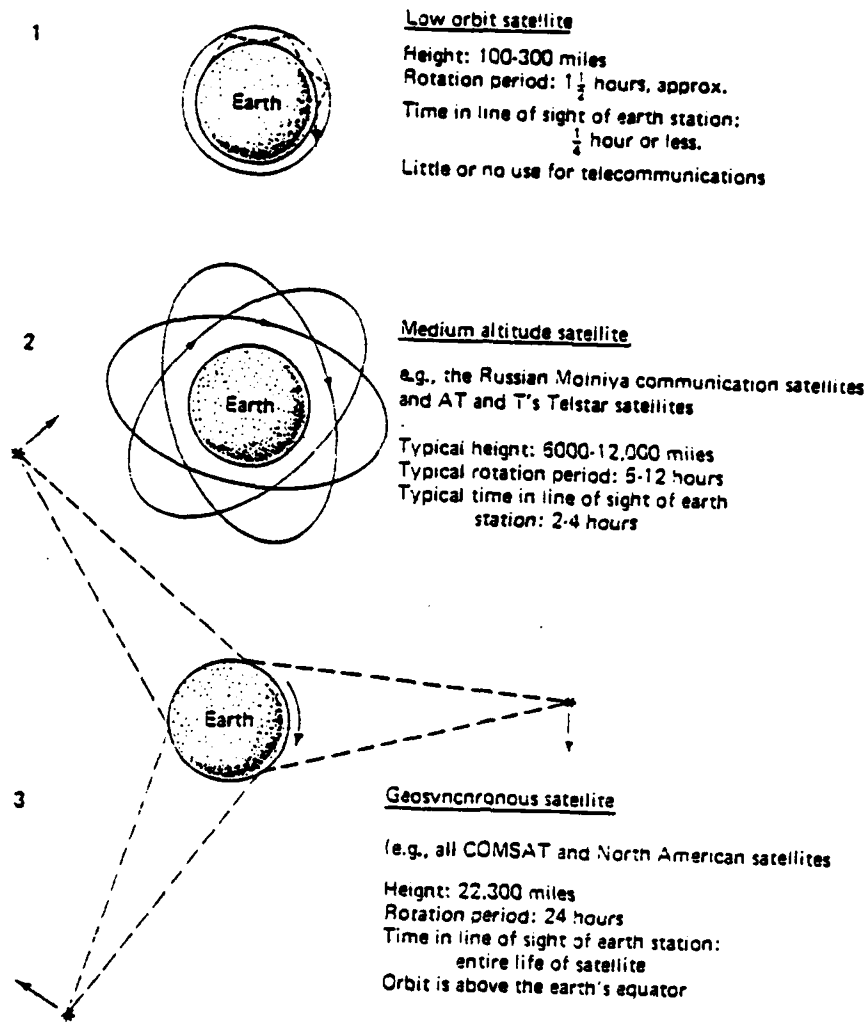


Figure 18. Satellite orbits

SOURCE: James Martin, Telecommunications and the Computer, 2nd ed. (Englewood Cliffs, New Jersey: Prentice Hall, 1976), p. 289.

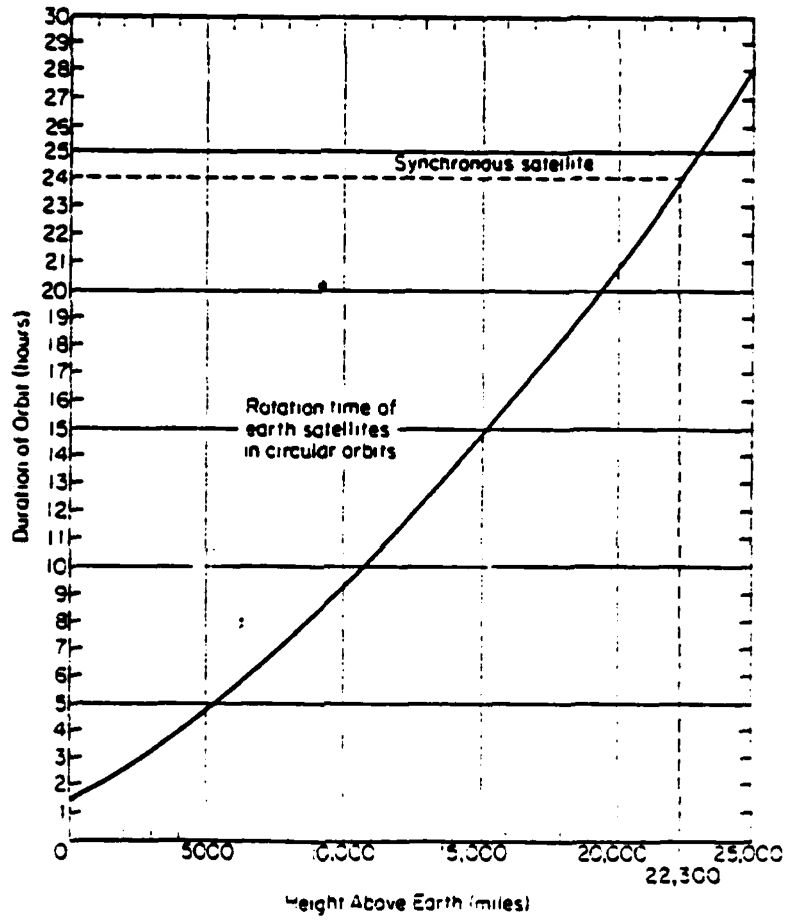


Figure 19. Rotation times of earth satellites in circular orbits.

SOURCE: James Martin, <u>Telecommunications and the Computer</u>, 2nd ed. (Englewood Cliffs, New Jersey: Prentice Hall, 1976), p. 288.

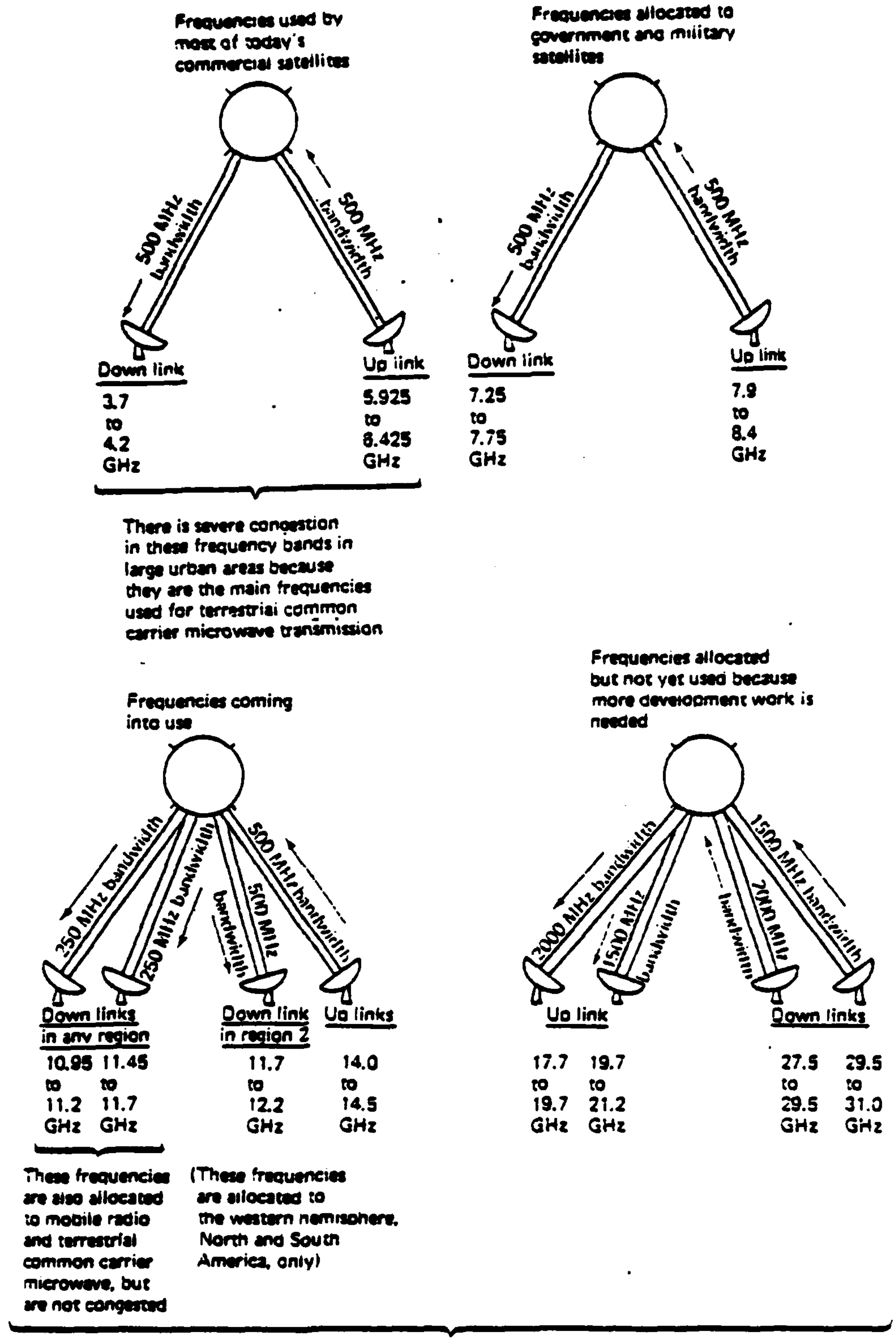


Figure 20. Communications satellite frequency allocations (250 MHz or more, below 40 MHz).

SOURCE: James Martin, Telecommunications and the Computer, 2nd ed. (Englewood Cliffs, New Jersey: Prentice Hall, 1976), p. 294, 295.

One disadvantage associated with satellite transmission is that a delay occurs because the signal has to travel from one earth station to the satellite and be retransmitted back down to earth for reception by another terminal. The signal delay occurs because of the long distance traveled by the signal from the ground to the satellite, 19,323 nautical miles (22,300 miles or 35,786 Km) above the earth's surface, and back down. The propogation time corresponding to a one-way, earth station to earth station, transmission is about 240 to 280 microseconds, depending upon location. This delay is about eight-times greater than the longest delay (35 microseconds) experienced on a coast-to-coast circuit in the U.S.[34]

This delay affects both voice and data communications. In voice communications the problem is of controlling echo, which may be objectionable to users. For certain data communications, efficiencies of the protocols used may be degraded severely over long-delay circuits. Conventional methods are employed to control echo for satellite circuits and coast-to-coast terrestrial circuits. In the case of a single-hop satellite, where the delay is not too long, the standard echo surpressor will do a creditable job on satellite circuits. A simplified diagram of such an echo surpressor is shown in Figure 21. Simply and briefly, an echo surpressor is a sophisticated electronic switch that compares the signals in the two directions of transmission, decides which customer is talking at a given instant, and places a very high loss in the return path of the talking subscriber. In a fast conversation, with the two customers interrupting one another, they may hear the echo

surpressors switching on the other's voice, sometimes in mid-sentence. This does not usually impair conversation seriously.[35]

In a double-hop satellite circuit (two satellite circuits in tandem), an echo canceller is employed instead of a surpressor. As shown in Figure 22, this device contains complex signal-processing circuits that compare the signals both directions of transmission and generate a replica of the echo. Instead of inserting loss into the return path, the canceller inserts the echo replica and subtracts it from the real echo. This action precisely cancels the echo, but allows speech to pass essentially unimpaired.[36] However, the echo canceller is more complex and more expensive than a surpressor, and the trade-off between them is extremely sensitive to a combination of price and performance factors.

The most effective method of satellite data communications for most applications is some form of "continuous" transmission, with an automatic-request-for-retransmission (ARQ) feature (continuous in this sense means that data blocks are transmitted one after another, without waiting for any acknowledgement from the receiving end). The device designed to perform continuous ARQ functions is called a Satellite Delay Compensation Unit (SDCU). Figure 23 is a simplified block diagram of a typical implementation of such a device. The business machine (or other data source) provides a data stream to the unit, which arranges the bits in blocks of predetermined size. As long as no ARQs are received, the data continues to be transmitted block by block.

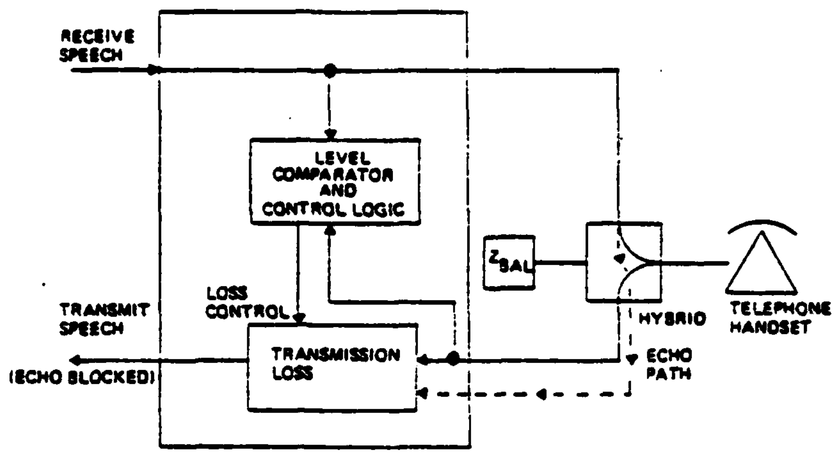


Figure 21. Simplified echo suppressor

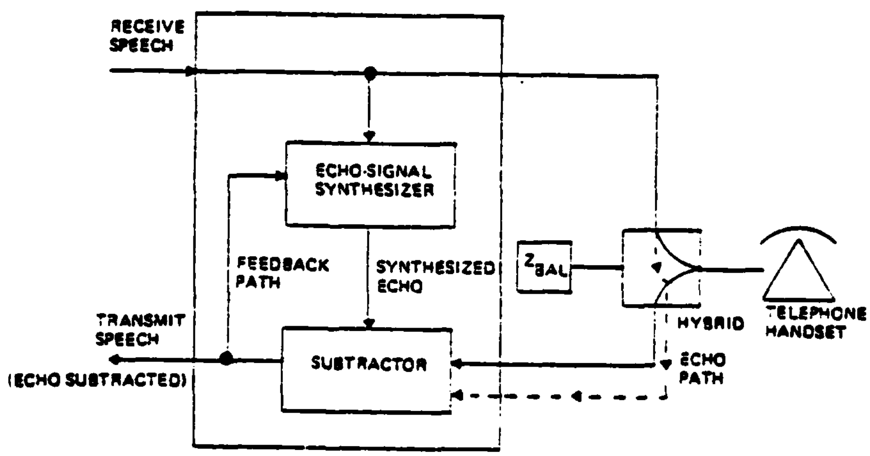


Figure 22. Simplified echo canceller

SOURCE: Joseph A. Sciulli, "Transmission-Delay Effects on Satellite Communications," Telecommunications, November 1978, p. 126.

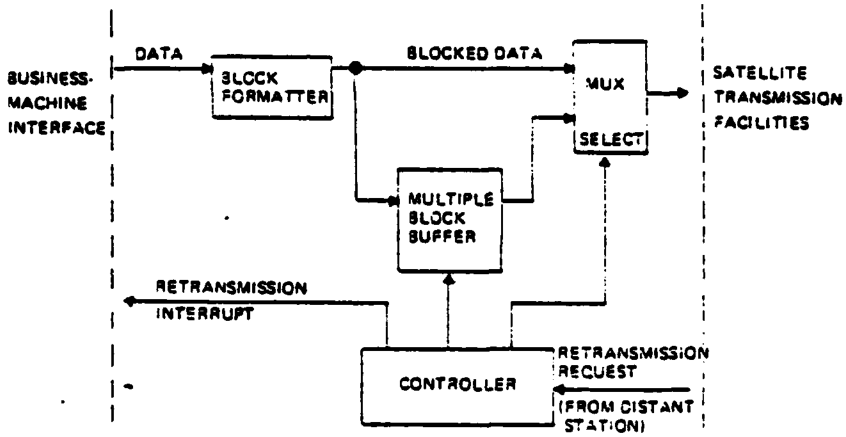


Figure 23. Simplified satellite delay-compensator

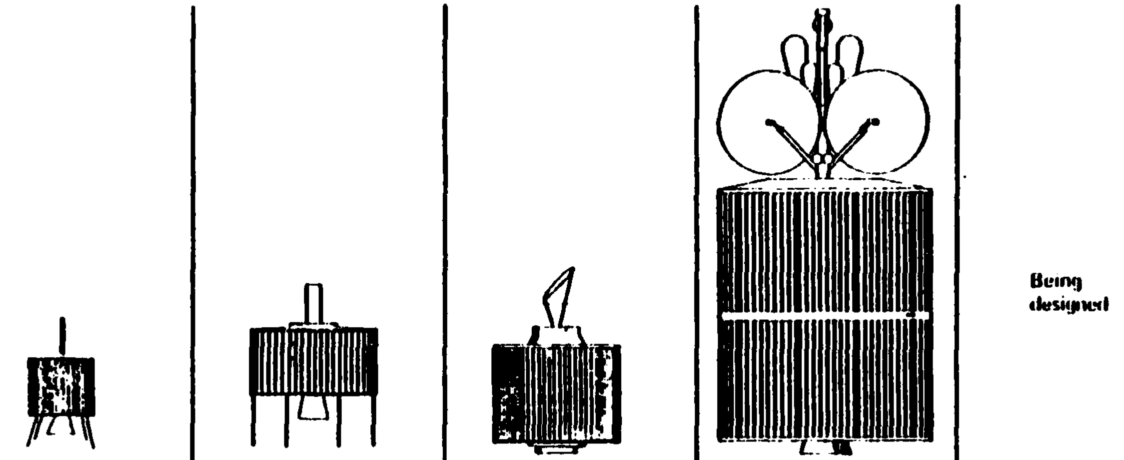
SOURCE: Joseph A. Sciulli, "Transimssion-Delay Effects on Satellite Communications," Telecommunications, November 1978, p. 127.

Whenever a block is received in error, an ARQ is generated and the transmitting end responds by interrupting transmission to retransmit some previous portion of the data.[37] The performance is governed by the interrelationship between several key parameters--error rate, data rate, block size, and required throughout efficiency.

Echo control and data transmission techniques in satellite communications have reached levels at which there is little doubt about the acceptability of the technical solutions in place or seen as technically feasible.

Cost Trends

Technological progress over the lifetime of INTELSAT operations has led to a dramatic reduction in the cost of communications satellites. At the bottom of Figure 24 is depicted the drop in cost per satellite voice channel per year. This process should continue with the advancing technological developments in satellites. Figure 25 plots the cost per voice channel per year, but it should be noted that this represents the investment cost of the satellite and its launch. The cost to the subscriber will be much higher because it must include the earth station and links to it, and must take into consideration the fact that the average channel utilization is lower than 100 percent. The cost of an earth station, however, has been dropping even more dramatically than that of a satellite. The first Comsat earth stations cost more than $10 million. Today a powerful transmit/receive facility can be purchased for under $100,000. Receive-only facilities are a fraction of this cost. At the same time, the traffic that can be



Name	Intelsat I (Early Bird)	Intelsat II	Intelsat III	Intelsat IV	Intelsat V
Year of launch	1965	1967	1968	1971	≈ 1979
Diameter	28 inches	56 inches	56 inches	93 inches	600 inch sails
Height	23 inches	26 inches	78 inches	111 inches	264 inches
Weight in orbit	85 lbs	192 lbs	322 lbs	1547 lbs	3200 lbs
Number of antennas	1	1	1	3	6
Primary power (watts)	40	75	120	400	1000
No. of transponders	2	1	2	12	27
Bandwidth of transponder	25 MHz	130 MHz	225 MHz	36 MHz	
Cost of satellite	$3.6 million	$3.5 million	$4.5 million	$14 million	~$ 25 million
Cost of launch	$4.6 million	$4.6 million	$6 million	$20 million	~$ 23 million
Design lifetime	1.5 years	3 years	5 years	7 years	10 years
Total cost per year	$5.47 million	$2.70 million	$1.90 million	$4.85 million	$ 4.8 million
Maximum No. of voice circuits	240	240	1200	6000	≈ 24,000
Cost/voice circuit/year	$23,000	$11,000	$1600	$810	≈ $200

Figure 24. INTELSAT satellites

SOURCE: James Martin, Telecommunications and the Computer, 2nd ed. (Englewood Cliffs, New Jersey: Prentice Hall, 1976, p. 284.

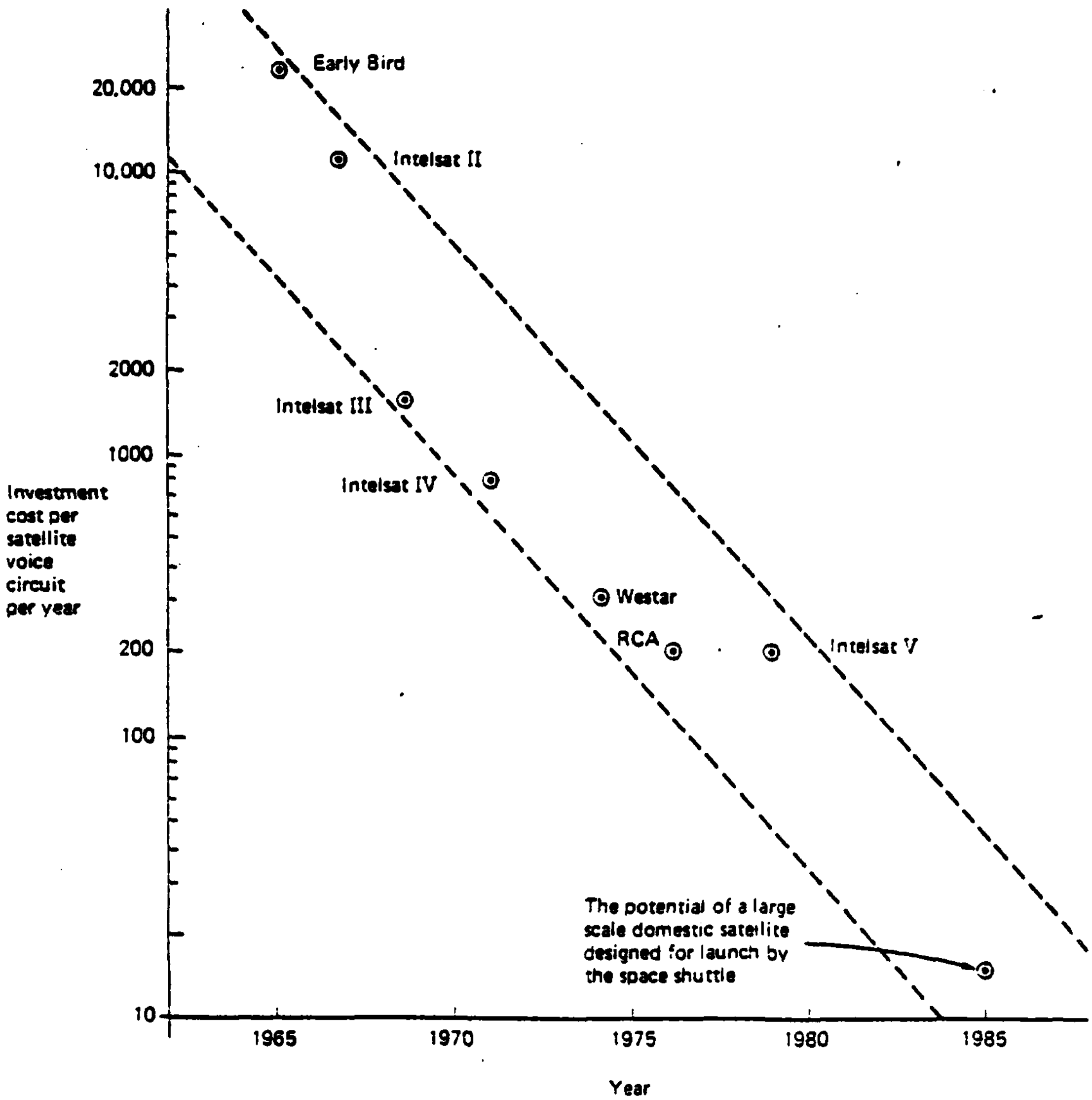


Figure 25. Dropping satellite costs per circuit

SOURCE: James Martin, Telecommunications and the Computer, 2nd ed. (Englewood Cliffs, New Jersey: Prentice Hall, 1976, p. 286.

handled by an earth station is increasing along with satellite-carrying capacities. Combining these two trends, we find the investment cost per channel for earth stations following the decreasing pattern illustrated in Figure 26.

The cost trends of earth stations and satellites is somewhat self-reinforcing. As earth terminal costs are reduced, the demand for them rises, more are constructed, and satellite use increases. This makes it more economical to use more and more powerful satellites, reducing the size and cost of the earth stations. So the cycle repeats.

Future Technology

The growth of satellite communications is considered a dramatic illustration of how the application of new technology can benefit all segments of society. New markets, and new jobs, have been created, while communications capabilities have increased and costs to the end user have decreased.

On the other hand, advances in communications satellite technology have also been stimulated by the mass and power constraints imposed by the launch vehicles. The advent of the space shuttle is likely to reduce these constraints on satellite growth, permitting technological advances to focus on communications-centered requirements.[38]

Problems have been addressed, such as the limitation on usable frequency spectrum and congestion in the geostationary orbit. The 4/6 Ghz arc, for example, is near capacity, and the 12/14 Ghz band is filling with applicants. Despite these apparent problems, the future appears bright.

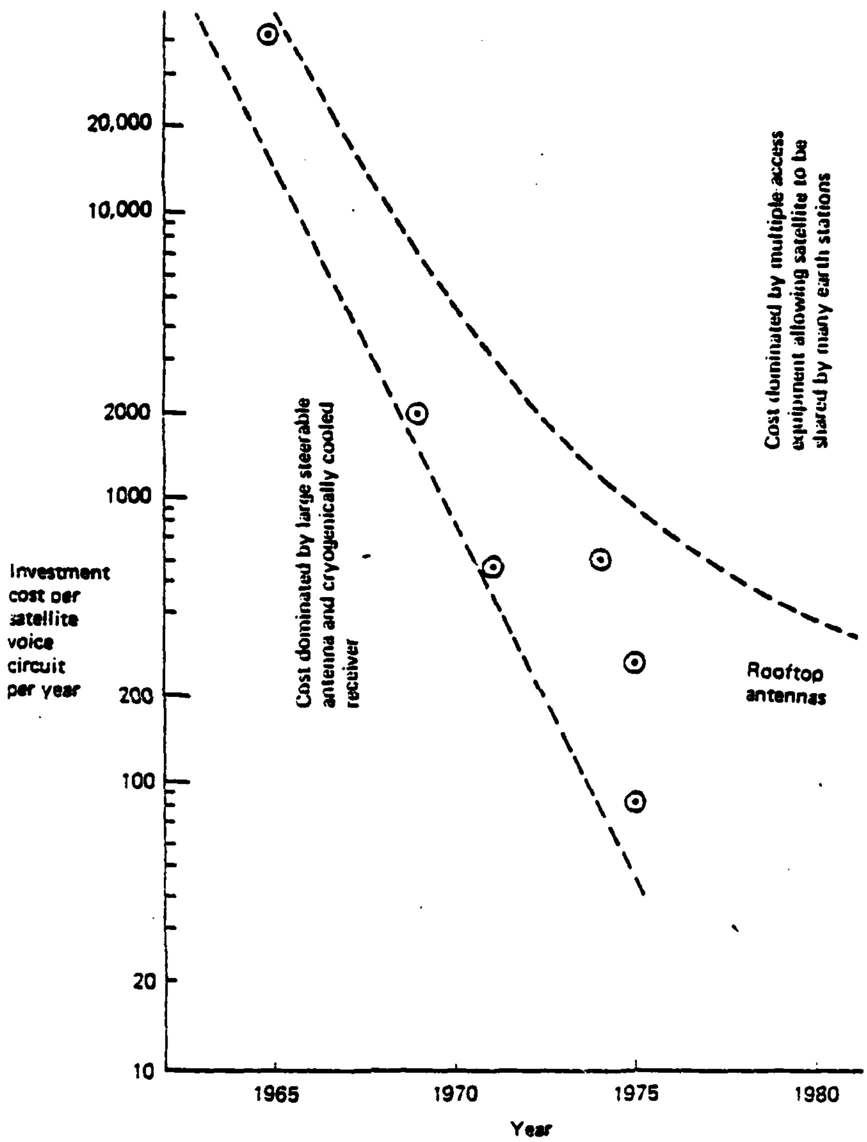


Figure 26. Dropping earth station costs per circuit

SOURCE: James Martin, Telecommunications and the Computer, 2nd ed. (Englewood Cliffs, New Jersey: Prentice Hall, 1976, p. 287.

One plan to cope with these problems of limited resources is the concept of component ownership on large space structures or platforms. The space platform solution will depend upon either increased throw weight in the satellite launching vehicle or upon construction of the platforms in space. The space shuttle will permit delivery of the components and personnel to space orbit, and only the addition of new techniques in space-located construction will be needed to realize the space platform.

Such a platform could contain a dozen or more transmission systems at the same geosynchronous orbit location. Spacing between platforms could be much closer than between current satellite systems because the ability to resupply them with fuel for orbital correction will allow more precise maintenance of orbital position.[39] In addition, with movement to higher frequencies, new multiple access techniques, and new diversity techniques, the limits imposed by the physical extent of the electromagnetic spectrum have been greatly reduced.

Multiple-access schemes are basically of three different types:

1. Frequency division multiple access (FDMA)
2. Time division multiple access (TDMA)
3. Wave form division multiple access--sometimes called code division multiple access (CDMA) or spread spectrum multiple access (SSMA).[40]

The various multiple-access techniques are identified by the manner in which they achieve separation of frequency bands or time intervals to the satellite.

An FDMA system makes available a pool of frequencies and assigns them, on demand, to users. A TDMA system makes available a

stream of time slots and assigns them, on demand, to the users. TDMA can handle more channels of voice or data, and is generally employed when the transmission mode is digital.[41] In Table 15 the more prominent advantages and disadvantages are presented for the various multiple-access techniques. The best choice really depends on the specific emphasis one places on the various characteristics. The real long-term advantages of FDMA are its bandwidth efficiency and spectral flexibility, which are becoming increasingly important when considering the limited physical spectrum resource. On the other hand, the power efficiency and potential reduction of system equipment costs make TDMA a very attractive multiple-access technique. SSMA can compete only when antijam protection demands it.[42] Use of such techniques will be an important factor in efficient use of satellite frequency and contribute to the continuing reduction in per-channel costs.

The typical satellite system with which we are concerned (those which will serve organizational management needs) typically use 56 kilobit digital modems, Field Effect Transister (FET) low-noise amplifiers in the 100 to 500 watt range based on either bi-phase or quadri-phase shift keying (BPSK or QPSK) as the modulation technique. QPSK was selected by Satellite Business System (SBS) for its new system.[43] These techniques present a cost advantage for development of digital networks especially for data. For that reason, Mr. Howard Crispin of Scientific Atlanta, Inc. has concluded that ". . . data transmission will be one of the fastest growing areas of satellite communications in the next five to ten years."[44]

TABLE 15

PARTICULAR SYSTEM CHARACTERISTICS OF FDMA, TDMA, AND SSMA

FDMA		TDMA		SSMA	
Advantages	Disadvantages	Advantages	Disadvantages	Advantages	Disadvantages
• Flexibility in Spectrum Allocation • Efficient Bandwidth Utilization for Large/Small Terminal Mix • Relaxed Requirements on Channel, Phase, and Amplitude • No Time Synchronization • Most Compatible With FH SSMA • Little Multiple-Access Overhead	• Linear Satellite Transponder Operations; Power Back-off • Intermodulation Sensitivity • Multiplicity of Terminal Equipments; Up/Down Converters, Modems • Simultaneous On-board Access Processing • Up-link Power Control Required • Up-link Margin Required	• Saturated Transponder Operations; No Back-off • No Intermodulation Problems • Single Chain of Terminal Equipments; Sequential Processing • Most Compatible With PN SSMA • No Up-link Power Center Required • No Up-link Margin Required • Single Chain On-board Processing	• Large-Bandwidth Requirements • Less Flexibility in Frequency Management • Bandwidth Inefficiency for Large/Small Terminal Mix • Tight-Synchronization Requirements • Some Multiple-Access Overhead	• Very Limited Multiple-Access Coordination Required • Little Sensitivity to Intermodulation • No Large/Small Terminal Mix Problem • Relaxed Requirements on Up-link Power Control • Anti-jam Protection	• Self-interference • Complex Equipments • Tight (PN) or Moderate (FH) Synchronization Requirements • Comparatively Long-Signal Acquisition

SOURCE: International Telecommunications Exposition, Exposition Proceedings (Dallas, Texas: Horizon House, February 26 - March 2, 1979), p. 374.

In the earth station area, another recent development promises to help hold down the cost of multiple-satellite systems. Comsat recently demonstrated an antenna design that can give space communications users the capability to receive simultaneous transmissions from as many as six satellites. This antenna, the Torus, as it is called, was demonstrated at the FCC for visitors after a six-month test period under a developmental authority permit. The main feature of the antenna is a nonsteerable fixed reflector, which is circular in design, along the direction of the equatorial arc. Inside a control room the feeds move on a track, and, because of the circular design, it is possible to create identical beams along the geostationary arc. Shifting the beam is all that is necessary to aim it. This fixed-reflector design is considered by its developers at Comsat to be an inexpensive means of generating more beam capacity at individual earth stations.[45]

More dramatic than multiple-access techniques and new types of earth stations, a recent report on the Air Force laser satellite to be launched in 1981 presents a graphic illustration of how technology can help overcome the limitations imposed by the physical extent of the electromagnetic spectrum.[46] Designed by McDonnell Douglas Astronautics Company, the laser transmitter tests are being conducted by the USAF Space and Missile Systems Organization. The laser possesses some unique advantages of importance in military applications. The intense, narrow laser beam enables the satellite to be positioned at altitudes above the usual synchronous orbit where attacks by hunter/killer satellites are made more difficult. The narrow beam has a secondary advantage of highly concentrated

area coverage, almost eliminating the possibility of intercept. Along with this advantage in covert operations, the laser's complete absence of RF emissions or side-lobe energy makes the satellite an extremely difficult target to locate. Finally, the high data rates possible with the laser transmitter not only will meet the Air Force requirements, but will be of great interest in future commercial applications as well. Already data rates of one giga-bit per second are being achieved, equivalent to transmission of the entire Encyclopedia Britancia every second, and the designers expect to reach multiple-giga-bit rates before the actual launch. The transmitter uses a direct digital modulation technique called Pulse Quarternary Modulation, a method employing a combination of pulse delay and pulse polarization modulation, using pulse widths of 300 picoseconds on a wavelength of 532 nanometers. With optical multiplexing, a rate of eight giga-bits per second is possible, although lower data rates might be employed when weather penetration is required. Data link terminals postulated for the system include those located in synchronous spacecraft, low altitude spacecraft, and aircraft, in addition to ground stations.[47]

The technology is available to overcome what were once thought to be serious problems of orbital crowding and limited spectrum. Much closer spacing of satellites in orbit is possible with high gain, spot-beam antennas and lasers. Space platforms, the use of higher frequencies, multiple-acess techniques, improved modulation methods, and innovative multiplexing over wider bandwidths hold the promose of very high data rates and total satellite capacity far beyond that thought possible a few years ago. The expansion

in satellite utilization, accounting for an estimated $100 billion revenues from communication/information services by the year 2000 in the estimate of Science Applications Incorporated,[48] is assured now that saturation of satellites has been put off well into the next century.

Switched Networks

> The time has arrived when we can communicate with anyone, just about anywhere in the world, by word of mouth, telegraph, data, facsimile, video, and whatever else will be announced tomorrow morning by another inventive manufacturer.[49]

With the increasing proliferation of large-scale integrated circuits and continuing drop in the cost of microprocessor technology and intelligent switching machines, numerous organizations around the world are implementing intelligent networks, based on the transmission techniques known as Packet Switching. For example, in the United States the "value added carriers" are in various stages of developing intelligent networks that will employ transmission techniques based on Packet Switching technology. In other countries, various governmental and private business concerns are also developing packet switched types of networks.[50] The definition of a packet and packet switching, as set by the CCITT, are as follows:

> Packet: A group of binary digits including data and call control signals which is switched as a composite whole. The data, call control signals, and possibly error control information, are arranged in a specified format.
>
> Packet Switching: The transmission of data by means of addressed packets whereby a transmission channel is occupied for the duration of the transmission of the Packet only. The channel is then available for use by packets being transferred between different data terminal equipment.[51]

(The data may be formatted into a packet or divided and then formatted into a number of packets for transmission and multiplexing purposes.)

Packet switching first came into experimental use at the end of the 1960's as a new type of store-and-forward switching. Packet switching is intended primarily for real-time machine-to-machine traffic, including terminal-to-computer connections, and is employed to build computer networks, whereas message switching is intended primarily for nonreal-time people-to-people traffic. These differences in purpose are such that there are major differences in operation between message-switching and packet-switching networks. The most important difference is the speed of the network: A packet-switched network may be expected to deliver its packet in a fraction of a second, while a message-switched system typically delivers its message in a fraction of an hour.[52]

In packet-switching networks, special purpose communications switching minicomputers are typically used in conjunction with leased lines; these minicomputers provide logical channels between user terminals and computers, or between computers. This shown in Figure 27. Messages from network users are accepted by the network minicomputers. Packets are transmitted through the network in store-and-forward fashion as shown in Figure 28. Each packet is individually handed forward along the best available path; it is completely error checked each time another wideband link is traversed. The minicomputers have sufficient intelligence to detect physical link or node outages and to dynamically reroute

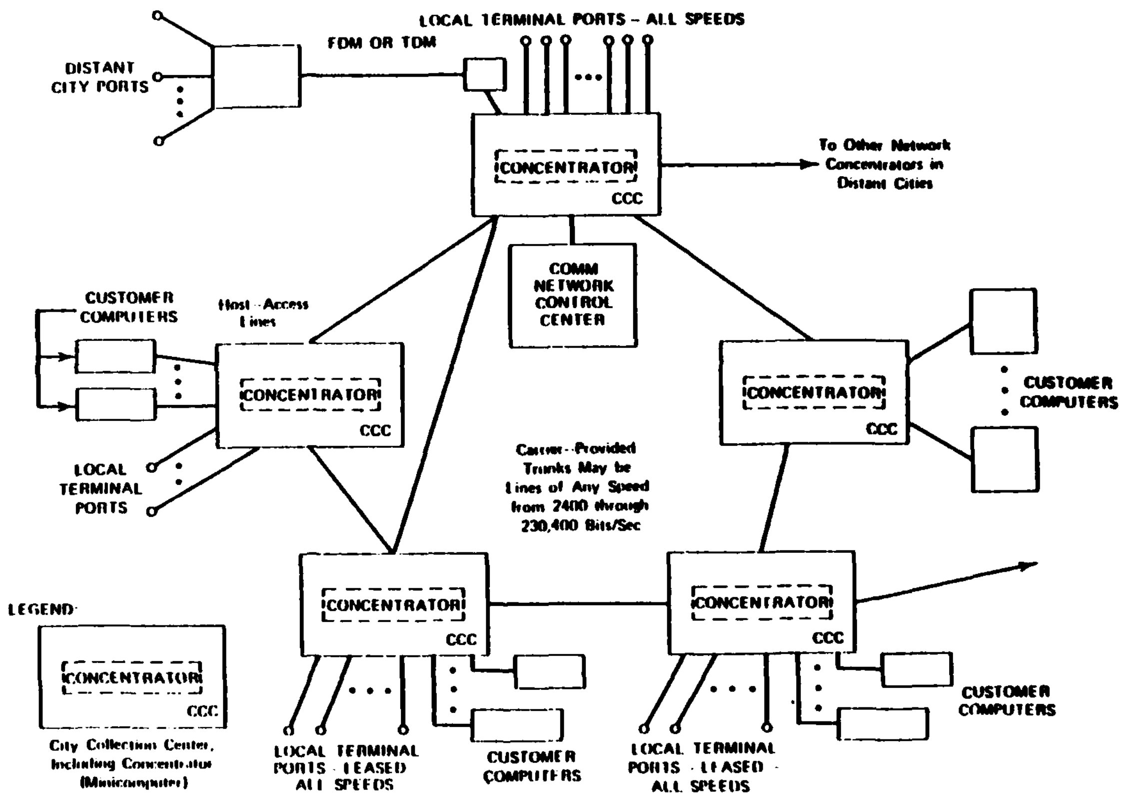


Figure 27. Typical packet switching network structure

SOURCE: Dixon Doll, Data Communications: Facilities, Networks, and System Design (New York: John Wiley and Sons, 1978), p. 403.

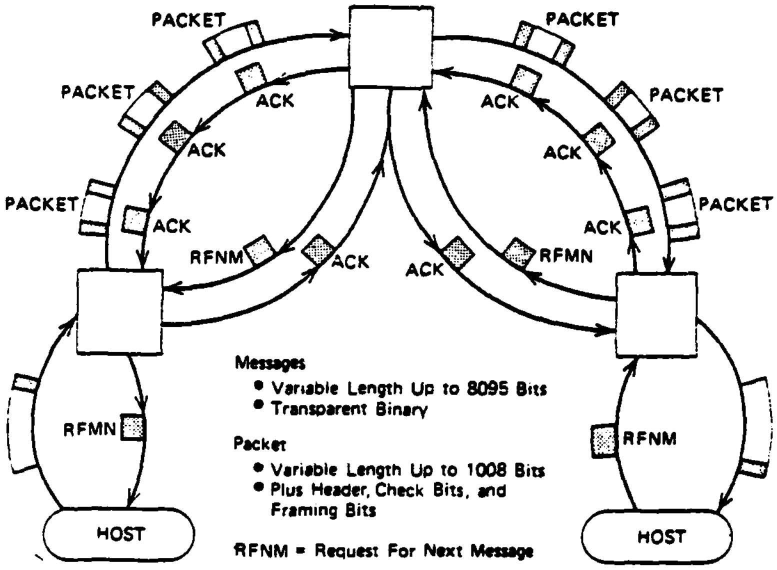


Figure 28. Packet switching between host computers

SOURCE: Dixon Doll, Data Communications: Facilities, Networks, and System Design (New York: John Wiley and Sons, 1978), p. 404.

packets over alternative paths. Complete messages are then reassembled from their constituent packets at the minicomputer, which interfaces with the destination user site. With packet switching, the relatively expensive wideband lines can be fully shared via the interleaving action that the packet switching achieves.[53] Packets may be thought of as envelopes into which data are placed. The envelope contains the desitination address and various control information. The transmission network computers should not interfere in any way with the data inside the envelopes. There is a maximum envelope size, and so, long messages have to be cut up into slices and sent in several envelopes. After transmission the slices must be joined together in the right sequence. Figure 29, shows the structure of a standard packet (Telenet or ARPANET). It has a maximum length of 1024 bits. The text (data being sent) is preceded by a start-of-message indicator and a 64 bit header. It is followed by an end of message indicator and 24 error-detection bits. The header contains the destination address; the source address; the link number and the packet number, which is used to ensure that no packets are lost and that packets in error are transmitted correctly; a message number with an indication of whether there is more of the message following in another packet; and some special purpose control bits.[54]

Routing Algorithms

When a packet switching computer receives a packet addressed to another location, it must determine to which of the neighboring nodes of the network the packet should be sent. The computer will

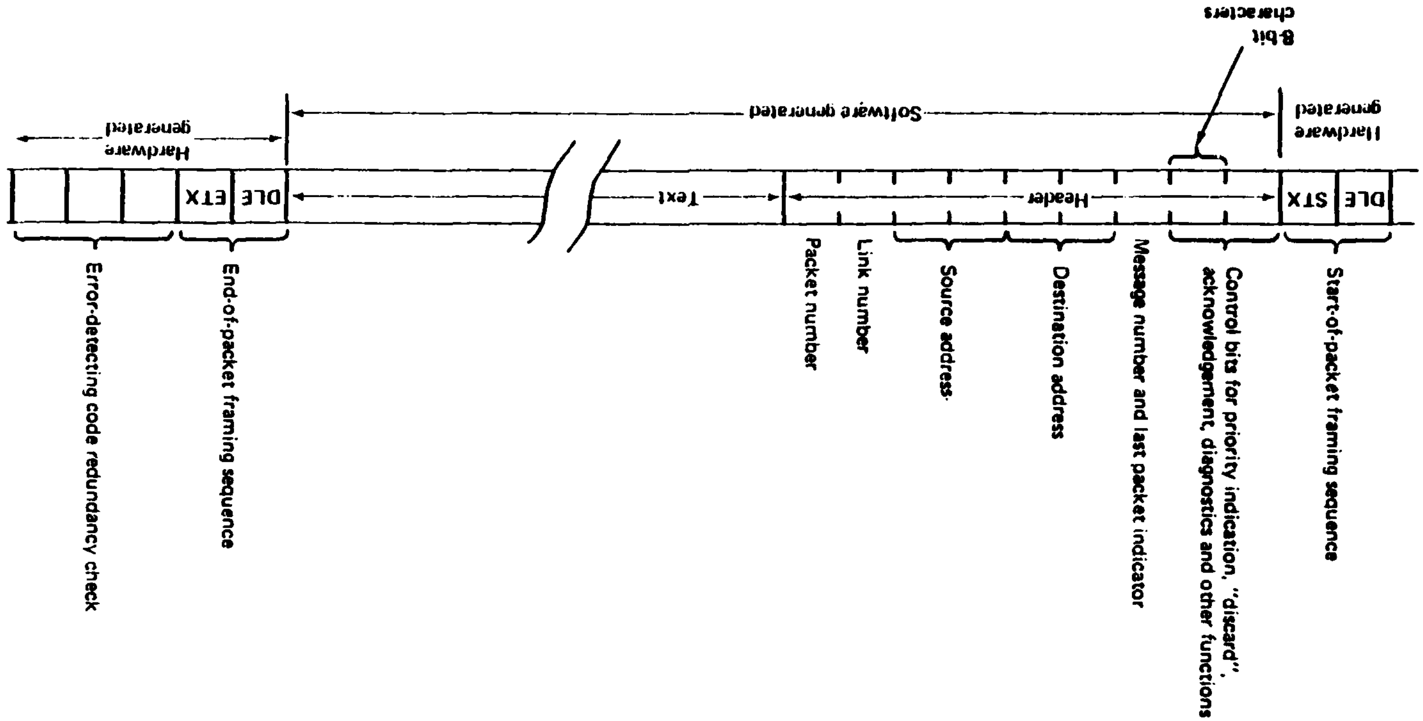


Figure 29. A typical packet format

SOURCE: James Martin, Telecommunication and the Computer, 2nd ed. (Englewood Cliffs, New Jersey, Prentice Hall, 1976), p. 461.

have a programmed procedure for routing the packet, and a variety of different routing strategies are possible:

1. Predetermined routing:

The route may be determined before the packet starts on its journey. The packet then carries routing information which tells the network computers where to send it. The determination of the route may be done by the originating location, or it may be done by a "master" station controlling the entire network.

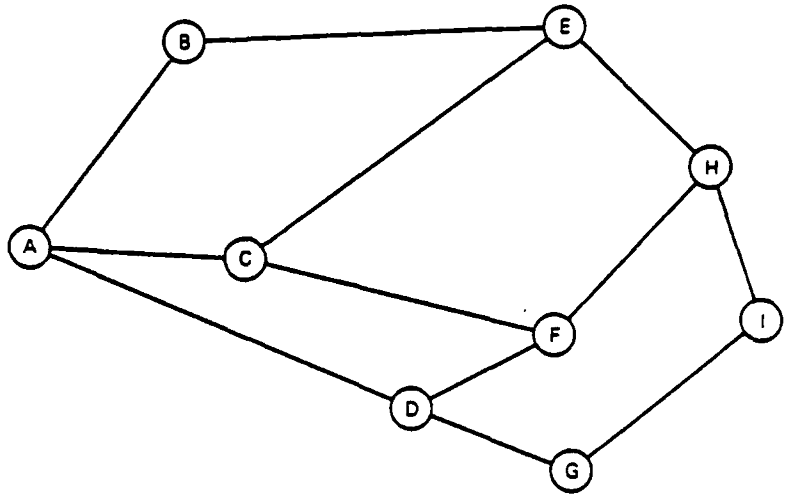
An alternative to predetermined routing is one in which each network computer makes its own routing decision for each packet. ARPANET and most proposed packet switching systems employ this nonpredetermined routing.

2. Calculated routing:

Here, the addresses of the destination nodes in a network may be chosen in such a way that it is possible for any interum node to determine which way to send a packet by performing a simple calculation on its address. Calculated routing is simple, but in general too inflexible, and hence unlikely to be used in practice.

3. Static directory routing:

With directory routing each node has a table telling it where to send a packet of a given destination. A possible form of such a table is depicted in Figure 30. The table shown gives a first-choice and a second-choice path. If the first-choice path is blocked or inoperative, a node will use the second choice path.



Packet destination	First choice node	Second choice node
A	A	F
B	A	E
D	A	F
E	E	A
F	F	A
G	F	A
H	E	F
I	E	F

Figure 30. A static routing table for node C for the above network

SOURCE: James Martin, Telecommunication and the Computer, 2nd ed. (Englewood Cliffs, New Jersey, Prentice Hall, 1976), p. 466.

4. Dynamic directory routing:

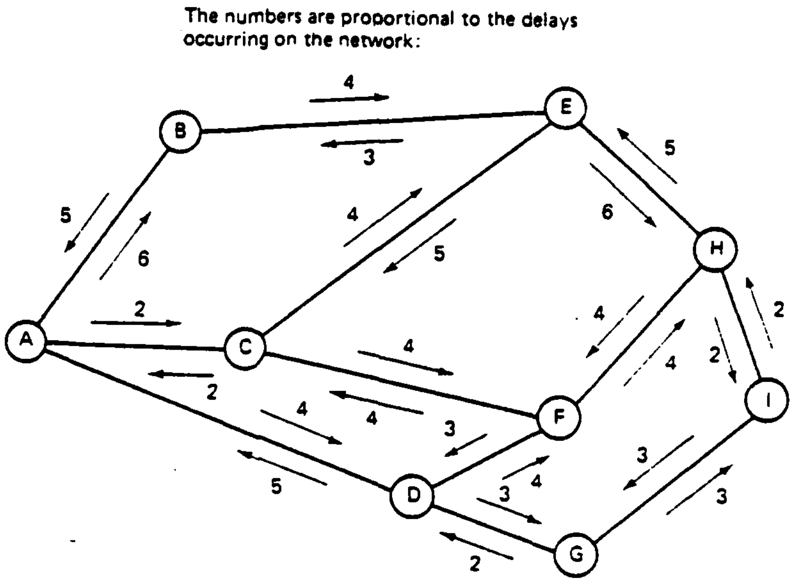
This is a more versatile method in which the table can be automatically changed as conditions of the network change. The possible criteria for selecting the entries for a table such as that in Figure 31 may include:

(a) choosing a route with the minimum number of nodes.

(b) choosing routes which tend to spread the traffic to avoid uneven loading.

(c) choosing a route giving a minimum delay under current network conditions.

This means that the table will be constantly modified to reflect the current delays on the network caused by congestion or failure. Figure 31 shows numbers proportional to the delays on the network at one time and a routing table for node C which takes these delays into consideration. As part of the time delay at each node is caused by queuing, the delays and the optimum routing table will change as the traffic patterns and volumes change. The question now arises: How should a node be informed of what the network delays are? Several methods have been suggested. One system is for each node to send a service message at intervals to each of its neighbors. The message will contain the time it was originated and also that node's knowledge of whether the delays have changed. The recipients will record how long the message took to reach them, and if this is substantially different from the previously recorded delay, they will include this information in the next service message they send. Knowledge of changes in transit times will thus be



Packet destination	Next node
A	A
B	E
D	A
E	E
F	F
G	A
H	F
I	F

Figure 31. A dynamic routing table for node C to minimize transit delays under above network conditions

SOURCE: James Martin, Telecommunication and the Computer, 2nd ed. (Englewood Cliffs, New Jersey, Prentice Hall, 1976), p. 467.

disseminated throughout the network.[55]

Adaptive routing:

This is a scheme in which the routes selected vary with the conditions of the network. The ARPA and Telenet networks use adaptive routing, each node sending a service message every half second. Most proposed public networks in other countries also use adaptive routing. This method sometimes results in oscillatory behavior, the routing pattern oscillating rapidly backwards and forwards under peak conditions. Minor changes in the routing algorithm can affect the routing behavior under heavy loading in ways which are difficult to predict without simulation of the network. It is possible that packets in such a network could fail to reach their destination because of temporary equipment failure or a data error in the address. Such packets might be passed indefinitely from one node to another if something did not stop them. To prevent this occurrence, a count field is used in each packet, and the number of nodes that have relayed that packet is recorded in it. When the counts exceed a certain number, the packet is returned to its point of origin. This process protects the network from becoming clogged with roving, undeliverable messages.[56]

VAN Services in the U.S.:

A series of FCC decisions in the past decade has provided the impetus of flood of new communications services which are still gathering momentum. The MCI decision in 1968, authority for establishment of packet communications, Inc. (PCI) in 1973, and the shared use and resale decision in 1976 have all given substance

to the FCC's campaign to stimulate innovation through competition in communications services. In the area of data communications, the PCI decision in 1973 led to the creation of a new class of carriers--the value added networks, or VANs.[57]

VAN services are in extensive use, considering the relatively short time they have been in existence. For example, packet switching (supplied by a VAN) is used by over 15 percent of the fortune 100/10 companies in the U.S. In 1977, according to the study "Value Added Network Services" by INPUT, the market for Data/Text/Image VAN services was $50 million, growing at 40 percent per year.[58]

The roster of VANs has grown--Telenet, Tymet, Graphnet, MCI, SPC, and ITT. AT&T has responded with new offerings of its own (discussed later in another chapter), enhanced private switched communications service (EPSCS), Transaction Network Service (TNS) and the highly publicized Advanced Communications System (ACS). Users initially proceeded with caution in checking the quality and reliability of new VAN services, but now they are boldly extending their usage. Tymnet's revenues grew 80 percent in 1977 to a figure in excess of $10 million, and this growth rate was reportedly being maintained in 1978. Telenet pegs its current growth rate at 8 percent/month. Industry studies project dramatic growth in the variety and usage of VAN services during the next decade--reaching billion dollar proportions during the 1980's.[59]

Before we analyze or describe some of the existing or proposed intelligent networks that utilize packet switching, here are some of the advantages and benefits to the new users. These

networks attracted users because they promised nationwide geographic coverage at a fraction of the cost of long-distance telephone, WATS or private leased line networks. But the advantages of using packet networks--public or private--go far beyond simple cost savings. A few of the other benefits inherent in packet communications services include:

<u>Lower error rates</u>:

Packet networks employ powerful error detection techniques that result in less than one undetected error in 10^{12} bits transmitted, which is seven orders of magnitude better than error detection techniques on a conventional telephone line.

<u>High availability</u>:

Packet networks are able to reach a very high level of reliability through a distributed network architecture, redundant network equipment and alternate routing capability. For example, each packet switching exchange in the Telenet network is typically connected to three or more other exchanges. Therefore, failure of any one link cannot interrupt user service, since data are automatically rerouted over another path.

<u>Equipment compatibility</u>:

Packet networks perform speed and code conversion to permit interconnection of customer equipment operating at different speeds with different formats.

<u>Network management</u>:

Many of the routine jobs in operating a communications network are assumed by the carrier. They include ordering, installation and maintenance of access lines and network-related monitoring

and control, and collection of accounting and traffic data. In the future, packet networks will be used to carry all kinds of data and possibly voice communications.[60]

Telenet

One example of a value added network is the Telenet Communications Corporation (Telenet), which was created by Bolt Beraneck and Newman, Inc. (BBN), and still remains its largest shareholder. BBN is the systemhouse which created ARPANET--the first major packet-switching network--just ten years ago. Telenet was formed early in 1973 and went public in December of 1977 with an $8.3 million public stock offering. It has extended its network and services since becoming operational in 1975. Presently 110 cities are served, and Telenet is installing third-generation packet-switching equipment throughout the network to further increase its flexibility and capacity for handling data and message traffic.[61]

Telenet supports dial-in asynchronous, dedicated and TWX connections to its network. Asynchronous connections support transmission at 110 to 300 bits/s and at 1.2 kilobits/s (10 to 30 characters and 120 characters respectively). The X.25 protocol which it uses is the CCITT standard for host computer interference and provides for high efficiency and transmission speeds. At present the X.25 protocol is used by the DataPac network in Canada, the overseas packet services offered in Hawaii and the United Kingdom, and will be included in every public network under development in the world today.[62]

High line utilization of the network is attained by dynamic

routing, which permits the distribution of the intranetwork data transmission workload evenly over all the nodes. The network is transparent to the terminal user.

Two types of host interfaces are available:

1) A network access processor-Telenet Processor (TP), installed at the customer's computer site, with up to seven simultaneously active asynchronous, low-speed remote terminals in the TP-1000 version. The TP-2200 version allows the use of thirty-two such network-access ports.

2) A packet-mode interface (X.25 protocol) which will support up to 255 asynchronous terminals at data rates from 110 bits/second to 1.2 kilobits/second.

Charges for Telenet services depend upon a variety of factors. There is a flat monthly charge plus a monthly usage charge. The monthly usage charge takes into account the number of dial-in hours that the user was on line plus the number of packets transmitted.[63]

Let us assume that a manufacturing firm has distributors in seventy-five U.S. locations, two of which are located outside of cities that offer local dial-in service. Each distributor has a 300 bps terminal with dial-in access through the Telenet Public Packet Network Service to a centralized order entry system at the firm's headquarters. Each such terminal has access to the computer for about 30 hours per month. The company interfaces its computer to the network, using an on-site Telenet processor (TP 2200) which it leases from the carrier, over a 4.8 kbps access line to the closest Telenet central office. The TP 2200 is configured with 24 asynchronous ports. This firm's monthly communications

charges are illustrated below.[64]

Rate Component	Monthly Cost
TP 2200 with 24 asynchronous ports	$1,050
Dedicated access facility (includes a 4.8 kbps leased access line, a port at the nearest Telenet central office and the associated modems or digital interface units)	800
Rotary feature	30
Monthly account charge	100
2190 public dial port hours at $3.25/hr	7,117
60 in-WATS dial port hours at $15.00/hr	900
Traffic charges at $.50 per 1000 packets of user data	1,125
Total monthly Telenet charges	$11,122 (prediscount)

This hypothical company also would be eligible for discounts on certain charges of about $5,000 a month. In the example above, the discount would reduce the total monthly bill to $9,398.10.

This example assumes a rather low traffic volume per location, making Telenet's public dial-in service the most economical alternative. However, for a firm which has multiple users in one city or high terminal utilization, private dial ports and leased line ports are offered which are billed to the user at flat monthly rates for unlimited usage. A new service called Private Packet Exchange (PPX) serves as a substitute for the user's multiplexor or concentrator in any city where a user has more than 300 hours of terminal usage. This allows the user a

correspondingly low rate per hour.[65]

Tymnet

Tymnet, Inc. is wholly owned by Tymshare, Inc., a major independent computer services vendor with 1977 revenues of $101 million. Tymnet was created as a private network in 1971 by Tymshare, Inc. to supply its needs for communications services. It has progressed by stages from a private network, to a shared-user network, to the present common carrier status and today has the largest revenue base of the data oriented VANs.[66]

Tymnet is a character-oriented network. It uses packets, as does Telenet, but the packets may contain data from multiple users. Also, there is no dynamic routing algorithm for the individual, 64-character packets. Rather, a path through the network is established at user log-in, and this path remains fixed for the duration of the logical connection. Establishment of the path is based on the most cost effective routing at time of log-in.

Tymnet has nodes in more than 130 cities, and because of economies of scale there are reduced rates for cities with higher density traffic. For all users Tymnet character charges are a substantial proportion of the monthly costs.

For high-data transmission efficiencies, Telenet would be consistently cheaper. But in the range where most terminals operate at present (15 to 30 thousand characters/second) the two are approximately equal, while Tymnet is the cheaper at lower efficiencies. A data transmission efficiency of 22 percent is the cut-off point for high-density Tymnet rates, while 7-to-8 percent is the cut-off for the low-density Tymnet locations; data transmission

efficiencies below the cut-off are cheaper with Tymnet, and above it with Telenet.[67]

Actual selection of a specific packet-switched network vendor, however, will depend on more than a comparison between Telenet and Tymnet. Several other VANS, including AT&T's Advanced Communication Service (ACS), Satellite Business Systems (SBS), and Xerox's XTEN system may soon provide competition that could prove still more cost effective, depending upon the specific services required.[68]

Intelligent Networks

Advanced Communication Service

In 1978, AT&T proposed its Advanced Communication Service (ACS) to the FCC. ACS is ". . . designed to handle information normally carried via corporate communications and public message networks. ACS delivers person-to-person(s) (point-to-point) messages, also being capable of handling data communications transactions from terminals to computers."[69]

One of the main problem areas that ACS is addressing is the inflexible systems presently configured throughout many corporate networks. "The need for ACS . . . is to eliminate the growing number of inflexible single function networks that end up wasting enormous amounts of both money and time. . . ."[70] "In ACS, the terminals and computers will function as separate entities, with the network acting as an intelligent interface." Over 100 terminal manufacturers producing 450 different makes will initially be supported.[71] This represents support for approximately

two-thirds of today's existing equipment. It is interesting to note that the "competition's" protocol will not be supported. "The initial AT&T offering is that devices employing IBM's SDLC protocol are not supported within ACS."[72]

Because it is an intelligent network,

> ACS will allow a 'decoupling' of the originating and receiving stations in a message transmission resulting in independence of terminals and hosts. This decoupling reduces the terminal communications support burden experienced by hosts in many user configurations. Moving this task [host provided communications management functions for terminals] into the network allows the host to accommodate a much larger range of terminals.[73]

Thus, ACS has taken a step in the right direction. For years, manufacturers have been deliberately designing equipment which is incompatible with equipment of other manufacturers. As proposed, ACS will join "incompatible" devices into one corporate network. Single function networks as presently configured will soon be a thing of the past.

"None of the ACS capabilities involves the alteration of the information content of messages or data entered into the network by the user."[74] This is an important aspect as it will help AT&T in receiving regulatory approval for ACS. The only alteration is the conversion of the customer's data into a code, speed, and protocol which is compatible to ACS.

Description of ACS Network

ACS is a network of computerized-switching centers (nodes) (See Figure 32). The switching center ". . . is the basic building block of the network. About four nodes were intended to be installed by 1979 with AT&T saying that 100 nodes will comprise

the network."[75] Then, as the need arises, additional nodes will be added to the system. "As the network expands, local nodes are placed into geographic groupings called regions and tandem switches are placed in each region."[76]

The node will be comprised of three elements: the data switch, the message manager and the access controllers. The data switch is a duplex minicomputer that "establishes logical paths through the network from origination to destination, directs the movement of information and monitors traffic flow."[77] It is the job of the message manager to "store and manage messages for customers. In addition, the message manager stores customer communication routines and system programs."[78] Access controllers are microprocessers classified as either network access controllers (NAC) or remote network access controllers (RNAC). NAC's terminate customer access lines providing "terminal and host support and furnish line handling capability by interfacing protocols supported by ACS and converting customer message data and commands into a network standard form."[79]

"Any one node will physically be connected to all other nodes by at least two disjoint paths." Thus, if one of the 56 Kbit/s internodal trunks were inoperable, the network's "internodal logical connectivity would remain complete."[80]

The nodes collect the data from the sending terminals and computers and packetize them. The message will be transmitted along one or more paths within the network. At the receiving node, the packets are collected and recoded into the language of the receiving equipment.

When the customer is located within an ACS serving area (100 metropolitan areas initially) the ACS access line is either analog or digital.

> Access also is via a private line service, Dataphone Digital Service (DDS) or telephone company-provided entrance facility when the user is outside an ACS serving area and via the public switched network through a dial-in port (either shared or dedicated) or a dial-out port (dedicated to the ACS user only).[81]

> Dedicated access channels, will be full-duplex for terminals operating at speeds up to 1800 bps asynchronous and 2400, 4800, and 9600 bps synchronous. In addition, host computer access will be provided at 5600 bps. Multipoint access channels will also be provided.[82]

Each means of access will vary in their speeds. They are as follows:

Type	Speed
Private Line	Up to 1.8 Kbit/s asynchronous and 2.4, 4.8, 7.2, 9.6 and 56 Kbit/s synchronous
DDS	2.4, 4.8, 0.6 and 56 Kbit/s synchronous
Public Switched	Dual access port at speeds up to 1.2 Kbit/s asynchronous and 2.4 and 4.8 Kbit/s synchronous

Operation of ACS

ACS has two modes of operating, the call mode and the message mode. In the former "the system enables bidirectional communications, which is used for inquiry/response and data communication." Here ". . . information travels in a point-to-point, bidirectional manner, with a single path established through the network to handle the transfer."[83] But it is the message mode that has stirred up great interest in the business community. "In the message mode, the sender communicates to a store-and-forward buffer

called the Message Storage Area (MSA). In turn, the MSA communicates to another buffer, the Message Arrival Area (MAA), which is under the control of the receiver." (See Figure 33) This eliminates the need for two people to be in contact to transfer information. Now instead of two executives playing "telephone tag" and leaving messages for each other to call back, the two will be in "contact" utilizing the message mode.

In the message mode the message is:

> Sent on a path into the system with a specified destination(s) and pattern of delivery. Variables include time and journalization. The sender specifies the address and time of delivery, along with type of record to be kept by the system.[84]

The features inherent in the message communications mode and the party (sender/receiver) who has control or use of these features include:

Features	Controlled by
Send message	sender
Notification of Message Delay	sender
Message Record Keeping	sender or receiver
Receive Message	receiver
Copy to	receiver
Message forward	receiver
Collect messages	receiver

Multiple authorizations can be assigned in the MSA or MAA, ". . . either one individual or groups of individuals can operate in a storage area sending or receiving." Thus, the system is transparent to the sender or receiver. Other features include: by option AT&T will provide ". . . a log that keeps historical data

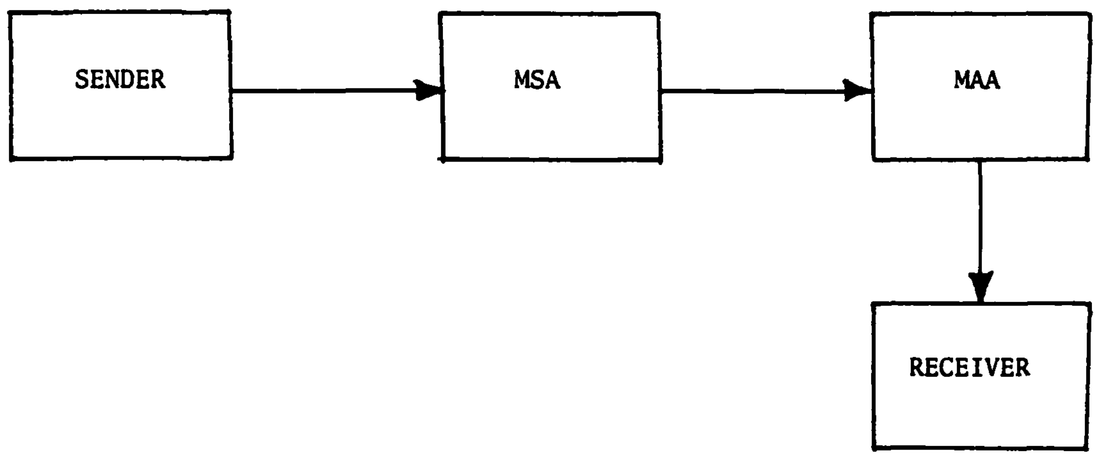


Figure 33. Message route

SOURCE: "A Natural: ACS and CWPs," EMMS, October 16, 1978, p. 2.

on messages sent/received, including the date/time, message identification, destination address, time of arrival (MAA) and time of withdrawal (MAA).[85]

"Using the ACS system, a word processing operator will be able to type in the receiving terminal's address, delivery time, and journalization. The system will do the rest."[86] Dr. Mark Rashkin, one of the key system designers, said that "there would be likely a directory of ACS users published, which would allow for random intercompany communications." Thus, AT&T might be closer to that all digital network than people realize, when you take into consideration that their all digital PBX is supposedly being developed "somewhere in Colorado."

Features of ACS

ACS will provide certain features which will render it attractive to the small and medium organization. The large user will find that it will be more economical to implement than their own network from the Bell System or an SBS type offering. The features provided ensure AT&T a viable market in data communications. Some of the features include:

1. Economies of scale--there will be no heavy start up costs associated with implementing ACS.

2. Intermix terminals and computer hardware--as previously mentioned many terminals and protocols will be supported.

3. Flexibility--users could form their own virtual subnetwork, fully accessible without the burden of operating and maintenance expenditures.

4. Redundancy--AT&T will provide duplicated data and tandem switches, message manager, links between nodes, and duplicate storage of data written in the MSA.[87]

Terminal Support

As stated previously ACS will support approximately 450 types of terminals manufactured by 100 different manufacturers (See Figure 34). Terminal incompatibility will become less and less of a problem. According to Data Management magazine, the five classes of terminals that ACS initially will support are as follows:

1. Asynchronous contention--character mode
2. Asynchronous contention--block mode
3. Asynchronous polled
4. Synchronous polled
5. Synchronous contention[88]

"The protocol support is called 'message level interface'. It allows the host computer to communicate with ACS on a 'message handler to message handler' basis with the host no longer required to support each remote station individually."[89]

Functions of ACS

AT&T has suggested seven functions of the ACS system. These include:

1. polling
2. device handline
3. broadcast mode
4. authorization procedures
5. format and validation routines
6. error recovery
7. journalizing[90]

Cost factors

"There will be four components in calculating an ACS user's bill."[91] They are as follows:

1. Number of packets or bytes transmitted.

   This will be used to measure the use of the transport facilities. According to Data Communications magazine, ". . . the cost of using the transport

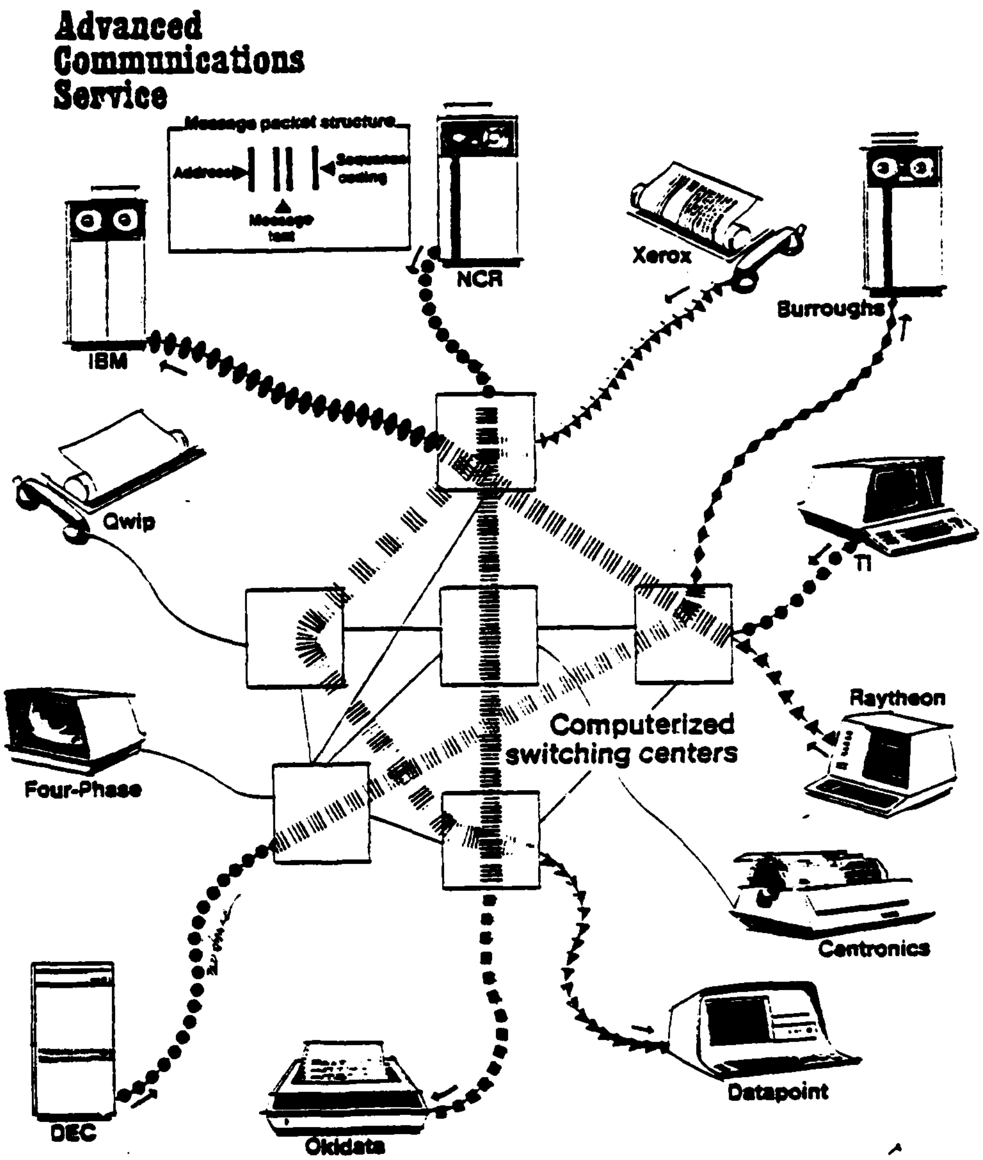


Figure 34. ACS network compatibility

facilities is essentially proportional to the number of packets or bytes using them."

2. Number of Network Resource Units (NRU) Utilized.

   NRU's will measure the amount and duration of demand storage. "Kilobytes of storage multiplied by some time unit will be used to measure the amount and duration of demand storage."

3. The kilobytes of network storage used as a function of a unit of time.

   The kilobyte or byte is the standard measurement.

4. Elapsed network time used by the customers.

   Elapsed time will be used in connection with public dial-in access, to allocate the cost of that access among the various users. Elapsed connect time measurement reflects cost causation directly, based on proportional use of dial-in ports which are shared by many users.

Potential for ACS

The potential for ACS is in the long run. Its value will increase with each new subscriber. Thus, AT&T has come up with a public, switched, intelligent, computerized, digital, flexible network. Due to the low start-up costs, ACS will be easily cost justified for the small and medium organizations. "Users with high-utilization networks operating in an SNA or other large mainframe communications architecture often will find it less costly to lease their own lines."[92]

The large organization will have to interconnect its own data transmission facilities up to the ACS network as it becomes more public. Its value would increase as each subscriber is added

to the network, just as is true with the telephone. "The result is that ACS will find its niche in a wide range of firms for applications involving the transmission of both terminal-to-computer transactions and terminal-to-terminal messages."[93] And AT&T sees this niche producing "revenues of a few hundred million by the mid 1980's."[94]

Satellite Business Systems

Satellite Business Systems (SBS) is a partnership comprised of IBM, Aetna and Comsat General. SBS has proposed a domestic satellite communications system serving "diverse organizations with large, complex communications requirements among multiple facilities." According to IDC the proposed SBS system "will provide users with switched, private line networks for transmission of image, voice and data traffic for government and business."[95]

Is IBM going into the common carrier business? Telecommunication analysts do not think so. IDC stated that "IBM's not in it for the bucks, even though it will gain a certain amount of revenues (from SBS.)" "Instead SBS will serve as a catalyst in shaping future communications technology."[96]

SBS Network

> The SBS system will be comprised of two satellites in orbit and hundreds of small earth stations with 16 foot and 23 foot antennas. [See Figure 35] It will provide integrated digital transmission, including voice, data, and wideband services, among dispersed business locations.

C. Thomas Rush, assistant director of marketing and applications and systems development at SBS said, "SBS is not a public network in the sense of serving everyone. Rather, it is a super

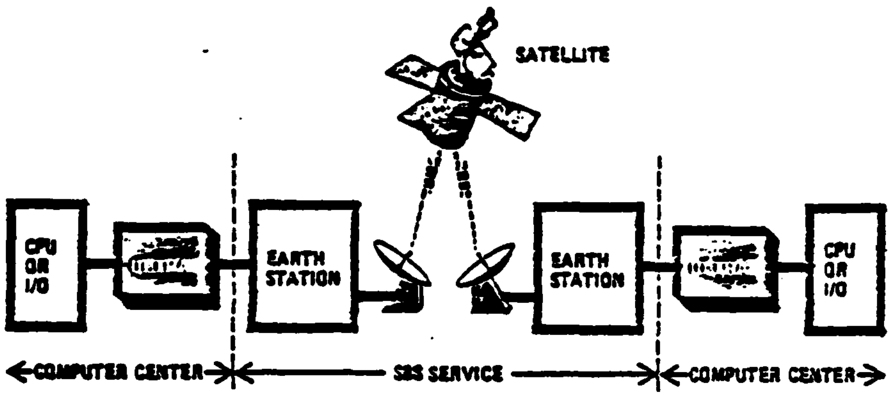


Figure 35. SBS system

SOURCE: "SBS Countdown Continues Despite Regulatory Haze," Data Communications, February 1979, p. 16.

backbone net."[97]

Plans are not definite as to how the customers will interface with the system. Rush states that "It is very likely that a common arrangement will be some sort of packet nodes at some SBS earth station locations. . . ."[98]

SBS will operate in the 12/14 GHz bands, "which are not shared with terrestrial services, [in order to] facilitate earth station construction.[99] Ultra-high-speed data exchange controllers--ultras--are located "between the satellite terminal and the customer's data and voice networks." Ultras ". . . are a sophisticated protocol converter and data buffer. . . ."[100]

Thus, system transparency will be achieved utilizing the ultras. The importance of network transparency will be discussed in Section III. There will also be "less-than-a-third-of-a-second delay in the actual satellite transmission." This will also help to render the system transparent to the user.

The big difference between SBS and ACS is SBS's ability to handle very high data rates.

> The smallest unit will be a 32 Kbit/s channel. The earth terminals at customer locations will operate at a basic data rate of 48 mbit/s and will be able to carry traffic at that rate if needed. Below capacity, data is sent in short bursts at the 48 mbit/s rate on a time-demand assignment basis.[101]

Functions and Features

SBS will function as a high data rate transmission facility. "The combination of customer-premises earth station, variable data rates on demand and dynamic allocation of capacity are unique to the SBS system. . . ."[102] "The system is one where the customer

will have 'full control' according to Rush. It provides point-to-point channels for the period of time that the job requires."[103]

Cost

There have been no indications from SBS as to how costs will be calculated for use of the system.

Potential

In order to judge the potential of SBS you must look at what their marketing strategy is. SBS is aimed at the large-scale organization. SBS chose 415 companies from the Fortune 500 and Fortune 50 listings when analyzing the feasibility and need for such a network. The heavy capital investment for customer-owned earth stations and the high speed and volume links offered makes this strategy obvious. But what isn't obvious is IBM's underlying intent in incorporating SBS. IDC has stated that ". . . SBS will serve as a catalyst in shaping future communications technology."[104]

IBM will be stimulating its sales in hardware, software, and services through SBS. An IDC report states that IBM ". . . is sure to benefit from large users' insatiable hunger for computer capacity which easily translates into more processors, peripherals, software and services."[105]

But the potential for SBS is not limited to stimulating IBM's existing market line. It will satisfy the need for future large-scale data transmission networks. "It is also felt that SBS will eventually offer more than just data transmission,"[106] according to Data Management magazine. SBS will be looking toward new applications to spur demand. An SBS spokesman mentioned

". . . that these could include electronic mail, teleconferencing, and direct channel-to-channel computer load-sharing."[107] Large-scale organizations have a need for the services offered by SBS. This will ensure that ". . . SBS should be well positioned as a vital linchpin in the transition from an information society to an information transfer society."[108]

Xerox Telecommunications Network

XTEN

Xerox has filed a petition with the FCC, asking them to set aside a little-used band of frequencies in the 10-gigahertz range for common carrier use. Xerox would like part of this proposed spectrum to be allocated to its new subsidiary Xerox Telecommunications Network (XTEN). "XTEN will offer high-speed end-to-end digital communications service throughout the nation."[109] Information available on XTEN is very limited and general. This section should be viewed accordingly.

Network

"The intercity backbone will utilize satellite transponders leased from current or proposed domestic satellite carriers.[110] (See Figure 36) From the earth station, terrestrial point-to-point microwave signals will be sent to city nodes which ". . . will use the new Electronic Message System (EMS) spectrum to communicate with stations located on the premises of individual subscribers." (See Figure 37) Each subscriber station (transceiver and equipment interface) "will have a minimum transmission rate of 256 Kb/s,"[111]

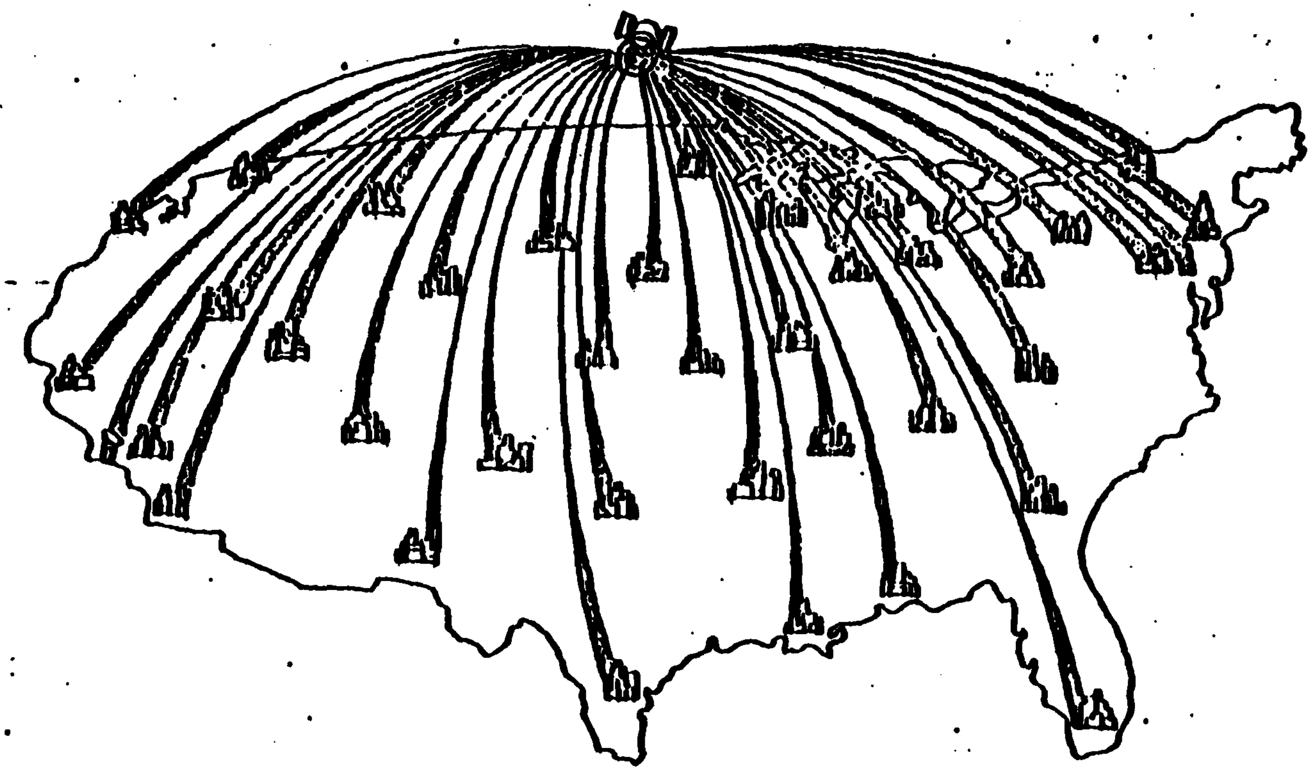


Figure 36. Proposed XTEN system

SOURCE: U.S. Federal Communications Commission, Xerox Corporation Petition for Rule Making Regarding the Xerox Telecommunications Network (XTEN). (Washington, D.C. [November 1971].

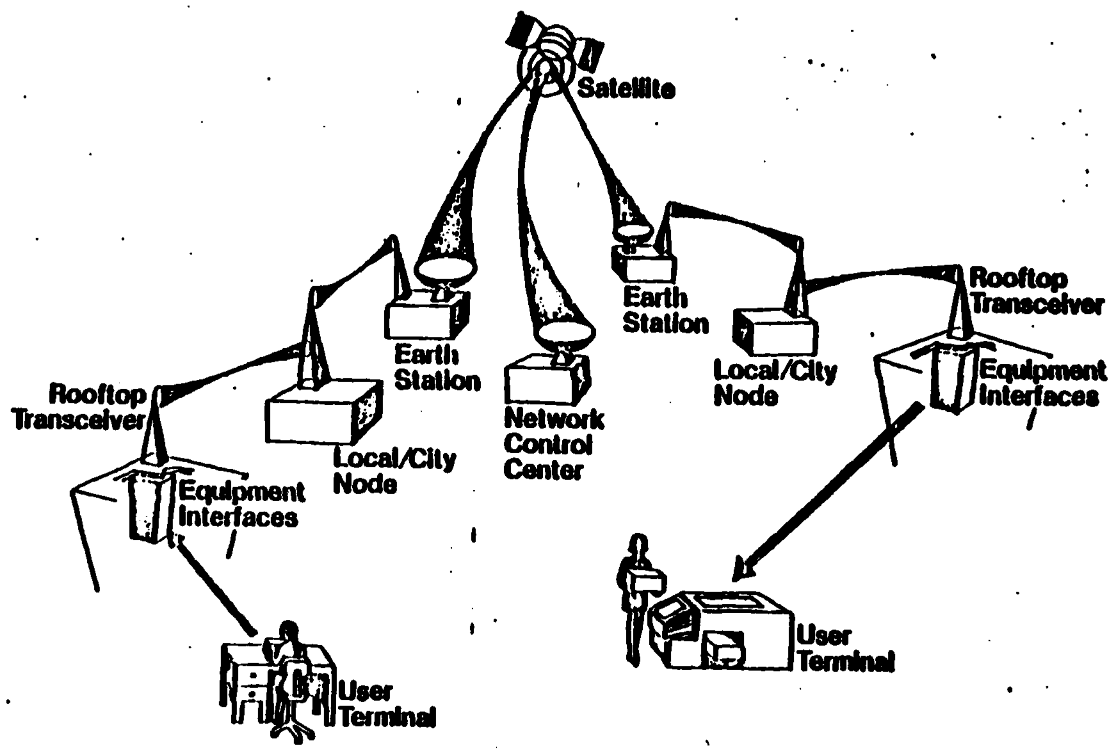


Figure 37. XTEN end-to-end description

SOURCE: U.S. Federal Communications Commission, Xerox Corporation Petition for Rule Making Regarding the Xerox Telecommunications Network (XTEN). (Washington, D.C. [November 1971].

"via a 10-gigahertz radio link."[112] "The entire nationwide system will be under the control of two network control centers."[113] This configuration will allow any subscriber to "communicate with any other subscriber. Xerox has stated that the network will eventually cover some 200 cities."[114]

XTEN Features

XTEN will offer many of the same features as ACS and SBS. The major difference will be start-up costs which will be discussed later. The features inherent in the XTEN network are as described in Xerox's petition to the FCC:

1. Store-and-Forward--XTEN will fully buffer all message traffic, allowing input to take place at any time and holding output until the receiving device is ready.

2. Priority Control--XTEN will offer delivery priorities ranging from immediate to overnight.

3. Multiple Distribution--With a single entry of repetitive information, XTEN will accomplish distribution to multiple addresses. For repetitive distributions, users need identify only a particular distribution list, rather than entering name and address information for each recipient.

4. Transparent Pipeline Service--A direct logical connection will be provided.

5. Security--Encryption will be used with the available option of password access and subscriber encryption.

6. Message Accountability--Subscribers will be provided an audit trial of system use. Missing documents will be returnable, for some period of time, from logs maintained at the XTEN control centers.

7. Device Compatibility--XTEN will provide speed, protocol and encoding conversion to permit the use of a wide variety of terminal devices.

8. Interconnection--Standardized interconnection arrangements will be offered for terminal devices of competing manufacturers.[115]

Cost

One of the major differences between XTEN, ACS and SBS is the customer start-up costs. ACS will be minimal, utilizing the AT&T network. SBS will require heavy capital investment as each customer will be required to purchase large, expensive earth stations. The initial customer capital requirement for XTEN will fall in between ACS and SBS. XTEN users will be required to have microwave antennas on their rooftops.

Potential

The potential for XTEN lies in the medium sized organization. Medium-sized firms will have provided for them all the functions necessary for future network applications. XTEN is a high-speed, integrated, intelligent, flexible digital transfer link. Some telecommunications analysts question Xerox's late entry and wonder if XTEN has a marketplace. Considering digital transmission growth expectations, the need is there not only for XTEN but other intelligent networks which will be required to transform our society from information processing to information transfer. No longer will the common carrier industry be dominated by one corporation. The networks of SBS and XTEN will be more cost effective to many firms as an alternative to AT&T is ACS.

B. Equipment

Computers

Large-scale, powerful computers long dominated the industry, and announcement of a new series or family of main-frame central

processors can still generate considerable excitement throughout the industry, as was the case with IBM's 4300 series. And as important as the 4300 series annoucement was, triggering over 50,000 orders the first day, or even considering the coming introduction of their large scale "H" series,[116] it is not the main frame which has led the revolution in communications applications. Gone are the ideas of a "computer utility," in which all the intelligence of a system would be contained within a gigantic central processor with dumb terminals slaved at the users' premises around a city or region. Today's concepts revolve around distributed processing, with a hierarchy of smaller computers sharing the load. As Mitchel J. St. Thomas explained in a recent Datamation article, "Much of the data that is transmitted to the central DP facility has already been processed, to some extent, by smaller processors in the field."[117]

> No single invention is so radically changing U.S. industry today as is the microprocessor, or computer on a chip . . . . . . Already, some thoughtful observers refer to the microprocessor as the engine that is powering a second industrial revolution.[118]

As the capacity and complexity of the miniature devices have grown, they have more and more taken over the tasks formerly performed by much larger, and more costly, devices.

The minicomputer had been well-positioned between the full-scale main-frame central processor and the microcomputers, but the overlap in capabilities and costs makes the distinction almost academic. In the words of the Vice-President for Marketing at Digital Equipment Corporation, the largest manufacturer of mini-computers, "The performance of a mid-range minicomputer is now

available at the price of a microcomputer."[119] In discussing the architecture of the Motorola 68000 microprocessor, Stritter and Gunter have observed that the circuit density of microprocessors has improved so steadily that "current processors have from 25,000 to 70,000 transistors, which is less than an order of magnitude away from the number in many of the largest maxicomputers."[120] Ralph Spencer of Digital Equipment Corporation hails the advent of the 32-bit VLSI microprocessor which will "enable the high-end minicomputers to provide performance features formerly available only in larger, more expensive mainframe computers.[121] But the "expensive" main frame may soon not be so costly either. Daniel Queyssac of Motorola Semiconductor Products recently observed that "the cost of computing power is dropping so drastically that by 1984 the capability of an IBM mainframe computer will be available for about $100."[122]

The devices which are a product of today's technology are a startling contrast to those of even just a year or two ago. Coming products may provide an equally startling contrast with those of today. Integrated circuit devices with capacities of 256,000 bits per chip should soon be available, as this is written, and one-megabit/second devices may be produced by 1982.[123] Dr. Thomas Longo, chief technical officer for Fairchild Semiconductor Corporation stated at the 1979 International Solid State Circuits Conference that the prospect for a CCD memory chip with 2-to-4 million bits by 1985 "is excellent."[124] Even further into the future, Dr. Amr Mohsen of Intel Corporation foresees chips with 100 million devices (transistors) in the 1990-2000 time frame.[125]

Without moving that far into the future to completely erase the distinction, already a more useful categorization of computers than by size or cost would be by function. It will remain useful to at least differentiate between a central processor and those subsidiary processors which see their application in memory access, input/output control, bus arbitration, memory segmentation, switching, remote processing, equipment control, and similar peripheral tasks.[126]

Two developments in semiconductor technology have led to the extremely bright outlook for the microprocessor; these are the charge-coupled device (CCD) and the magnetic bubble memory.

The CCD is a variant of the metal-oxide semiconductor (MOS), and it is the CCD which is expected to provide the very high number of devices per chip mentioned earlier. Their access times of under a millisecond are important in high-performance applications, chiefly larger computers, although their use in signal processing and imaging is also contemplated. An interesting application is as a buffer, main memory, device between the mass storage device and the CPU memory. Since data retention is volatile, however, the CCD is not suited to all applications. It also remains to be seen whether the extremely high capacities projected for the mid-1980's will actually be achieved. Reports of CCD shift registers with storage cells 33 to 65 square microns in size, and packing densities equivalent to 10-20 million per square inch indicate that the projections are not completely baseless.[127]

The other development, with greater significance for microprocessors, is the magnetic bubble memory. While progress

appeared to have fallen behind earlier optimistic predictions, development now seems to be back on track, more than a decade after their original emergence from the Bell Telephone Laboratories. Formerly the magnetic bubbles were contained within a thin film of gàrnet between a pair of coils. In the newer process a pattern of oval-shaped holes is etched into conducting layers, and the bubbles are formed around the holes whenever an electric current is applied. The coils have been eliminated.[128] Memory densities have been increased by a factor of four, and speeds are ten-times faster than in the older devices.[129] IBM's Jan Jose Research Laboratory, with Dr. Ta-Lin Hsu heading the team, has also increased the capacity of the magnetic bubble chip by a factor of four, but with an entirely different technique. The chief differences are the addition of special encoding and decoding stations and the use of two different types of bubbles rather than the indistinguishable bubbles in conventional devices. Information can then be represented by the differences in the bubbles themselves, rather than by the simple presence or absence of a bubble. At the limit, a one centimeter square chip is capable of storing up to four million bits. Fully operational experimental devices at a density of 3.3 million per square centimeter (22 million bubbles per square inch) are being tested by IBM.[130] Applications for the bubble memory will be chiefly in microprocessor based equipment, as in the replacement of cartridges and floppy disks, and in special applications where non-volatile memory is a consideration.[131]

It would be difficult to mention all the applications which have been found for the nearly 100 million microprocessors which are

estimated to be produced annually,[132] but the range includes everything from home entertainment devices and inexpensive small computers to word processors. Even the great promise of optical computing is now threatened by the prospect of low-cost, VLSI micro-computer modules in large array processors (optical computing is one in which information is mainipulated or processed by an optical wavefront, using a coherent light source).[133]

Computers thus play a role when information processing is involved. Their place in information transfer is equally well-assured, as in the existence of the already large number of networks which rely on computers for processing and switching. Leonard Kleinrock believes that the national networks will rapidly interconnect into a world network and hasten the widespread acceptance and application of teleprocessing and networking by the entire business sector of the economy.[134] Distributed processing, with computer arrays in a "star," hierarchial, or "tree" network, provides the case in which both information processing and transfer are involved. The use of the subsidiary computers, as for communication processors, in a distributed network "can free a system's mainframe from data communications overhead, which can account for as much as 40 percent of the CPU's processing capability, thereby allowing the mainframe to concentrate on the user applications for which it was designed."[135] Whether in processing or transfer, however, the applications of present and future computer technology are only at their beginning.

Word Processors

Word processing (WP), just like "electronic mail," "office of the future," and the popular office conjures up a different meaning for different people. The most accurate definition of WP is ". . . the transition of written, verbal, or recorded ideas into typewritten, printed, or electronically stored form, with the manipulation and distribution accomplished by the application of modern electronic and management techniques."[136] This section will cover communicating word processors, (CWP's), which comprise a small but explosive segment of the whole word-processing field. This explosive growth can be seen when we look at overall WP history.

The WP industry began at the turn of the century with the introduction of the mechanical typewriter. The automatic typewriter was introduced in the 1930's, but it was not until 1964 when IBM introduced its Magnetic Tape Selectric Typewriter that WP began to develop. It had taken over half a decade to get to this point. In the next 15 years, the rapid expansion began. Cathode Ray Tubes (CRTs), optical character recognition (OCR) were a couple of the major developments that stimulated WP sales. One of the most significant improvements was the communications option, which is available on most word-processing systems today.

A communicating word processor does just what it says. It communicates (transfers information) with mainframe computers terminals, other CWP's and compatible equipment. The ability to access and transfer this information will ensure that CWP's will play a large role in the years to come. As speed and quantity of

available information increases, so will the span of management control, secretarial efficiency and information decision making. These will increase further as the flexibility and features of CWP's become more attuned to the organization and its people.

Advantages and Features

Just as calculators have replaced bulky desk-top adding machines, CWP will be an important tool in replacing outdated existing equipment. One type of equipment which CWP will replace in many applications will be facsimile. Reasons for this include the following advantages for communicating word processors:

1. Superior speed
2. Superior output quality
3. Hard copy is unnecessary but required for facsimile
4. A communications option on CWP's is inexpensive ($500-$3500)

Potential

Word processing and in particular communicating word processors are in their infancy stages of development. EMMS magazine has stated that word processors have only saturated 1 percent of the available market.[137]

CWP's have shown phenominal growth rates over the past few years. Yankee Group predicts CWP's will increase 95 percent in 1979 over 1978's installed base.[138] This trend is expected to increase due to:

1. The introduction of intelligent networks
2. Increasing knowle ge of users
3. Decreases in cost
4. More applications and increased flexibility

In order for CWP's to sustain the predicted growth rates, manufacturers will have to pay closer attention to the flexibility of functions and applications. The needs of the organization and its workers will have to be incorporated into CWP's into one integrated function. This is starting to happen as "integrated systems are beginning to appear. . . ."[139] CWP's will mature until ". . . word processing, image processing, electronic files and voice communication are combined into remarkably versatile and powerful information storage and communication facilities."[140]

Private Branch Exchanges

A Private Branch Exchange, or PBX, is a circuit-switching system which provides service to one user organization. Usually located at the user's site, PBXs have traditionally provided basic voice-switching services. Such devices may function equally well as line-switching concentrators for computer communication applications especially with the advance in computer and semiconductor technology which have provided the means for a new generation of business-oriented advanced digital PABX's. The traditional PBX has three classes of ports: (1) station users or extentions, which are telephones connected directly to the switch; (2) attendants; and (3) trunks, which connect the switch to the public switched-telephone network or to other private networks.

The PBX usually routes incoming calls to attendant positions, from which they may be extended to station users; allows for station-to-station calling without the use of the telephone networks; and allows station users to access the telephone network for outgoing calls.

Today's advanced PBXs are universally computer controlled, using machines ranging from 3-bit microprocessors to 32-bit medium-scale computers, and perform functions sufficiently complex to require operation systems and application software of significant scale. The most common switching method for PBXs introduced in the last few years is time-division multiplexing of sampled digital representations of the input signal by pulse code modulation (PCM).[141] There does seem to be, however, a definite trend towards PBX compatibility with the transmission method already well-established by common carriers, namely, the T1 carrier which carries 24-voice channels on a 1.544-MBPS stream. Multiplexers used in T1 transmission can replace the one-voice channel with one standard 56-kbps data channel or five 9.6-kb, ten 4.8-kb, etc. This T1-carrier compatibility will assume greater importance as integrated voice/data networks become increasingly popular. Certain digital PABXs then will have the potential for direct, modem-less data switching.[142]

Adequate, versatile PBX equipment for direct digital, as well as analog, switching is just arriving. Conventional handling of digital data through even advanced switches can be torturous, as in the Rolm VICBX. Digital information in this switch is converted to analog at switch entry, reconverted to digital for actual

switching, and then reconverted to analog as the information leaves the switch. If a digital channel is to be used for transmission, the information must go through still another modem for reconversion to digital form.[143]

Pointing towards the future is the Data Feature option available with Northern Telecom's SL-1 PBX, a feature which allows voice and data transmission over the same extension without the extensive reconversions between analog and digital. It is anticipated that PBXs incorporating data handling features into the original architecture will be available in the near future.[144]

Features available with PBXs are extensive and growing. Table 16 adapted from Martin, is not meant to be comprehensive, but provides an indication of the variety of options obtainable.[145]

Voice Recognition Systems (VRS)

Speech, as a method of data capture, is not new. Right from the early days of computers it was recognized as the most natural form of getting information into the machine. In the past, the problem has always been the technology--how do you get a machine to recognize a natural human speaking voice and extract the information? These days, technology is no more a problem, and voice recognition systems are already in the marketplace, provided by NEC, Interatate Electronics, and others.

A voice recognition system is the most natural and simplest form of man-machine communication. It has the following features:

TABLE 16

FEATURES AVAILABLE WITH PBXs

Features of some conventional PBXs

* *Attendant's consoles*
  Operators at one or more consoles assist with the switching of calls. Varying numbers of switching functions are automatic.

* *Push-button station selection*
  The attendant has a status light and button for each station controlled.

* *Station-to-station dialing*
  A station can dial any other station attached to the PBX without assistance from the attendant.

* *Direct outward dialing*
  A station can dial a call on the public network without assistance from the attendant.

* *Station hunting*
  There are several lines to the PBX location. When the first line dialed is busy, the others are tried.

* *Call transfer by attendant*
  A station receiving a call can signal the attendant and request that the call be transferred to another station.

* *Call stacking ("camp-on") by attendant*
  When one or more calls are received for a station which is already busy, the attendant can put the calls in a waiting state until the station is free.

* *Call waiting ("camp-on") signal*
  A person receiving a call can be signaled to inform him that another call is waiting.

* *Conference calls*
  Calls between more than two telephones can be connected by the attendant.

* *Night service*
  The external lines serving the PBX can each be switched through to a certain station when there is no attendant.

TABLE 16 (cont'd.)

* *Power failure transfer*
  Certain prearranged stations can continue operation when there is a commercial power failure.

* *Station restriction*
  Designated stations are prevented from making outgoing calls.

* *Secretary consoles*
  A secretary can have a console for handling the calls of one or more employees.

* *Key telephone stations linked to secretaries*
  An employee can signal his secretary and vice versa. Secretaries can intercept calls.

Additional features of the Bell System Centrex II Package

* *Each station has its own external telephone number*

* *Direct inward dialing*
  Stations can be dialed from the outside without intervention by the attendant.

* *Call transfer*
  A station can transfer a call from the outside to another station without assistance of the attendant.

* *Consultation hold*
  A user can place a call on "hold" while he dials another station: he can then return to the interrupted call.

* *Third-party add-on*
  A user receiving a call can dial another station, thereby setting up a three-way conference call.

* *Night answering service*
  When the attendant console is unoccupied any station may answer incoming calls by dialing a code.

* *Listing of charges incurred by stations*
  A listing is provided for each station of the nonlocal calls dialed, giving the number, time, duration, and cost of each call.

TABLE 16 (cont'd.)

Other desirable PBX features offered on some computerized systems

* *Automatic call forwarding*
  A person may go to a different location and inform the PBX of its extension number; PBX will forward his calls to that number.

* *Automatic call stacking*
  When calls arrive for a station which is busy they will be automatically queried, possibly with a spoken "wait" message being played to the caller.

* *Automatic call distribution*
  When calls may be answered by any of a group of stations the calls are automatically distributed to the first free station.

* *Automatic call back*
  When a user places a call and the number is busy, the user may instruct the PBX to call him back when it is free.

* *External number repetition*
  When a user dials along number and it is busy, the user may instruct the PBX to remember the number so that it can repeat the dialing.

* *External conference calls dialed by individual stations*
  A user can set up an external conference call with the help of the attendant.

* *Users who move can retain their numbers*
  The number can apply to a new station without rewiring, merely by changing the tables used by the PBX.

* *Distinctive ringing*
  Different ringing tones are used for different categories of calls, for example internal, external, secretary, a call from a given extension, a call from head office. The user is thus given some indication where the call is from before he picks up his phone.

* *Pushbutton to dial pulse conversion*
  Signaling conversion is performed so that pushbutton telephones can be used even when the local central office accepts only rotary-dial pulsing.

* *Timed operator reminders*
  If an operator rings an extension which does not answer, the operator will be alerted after 30 seconds; the caller is not kept waiting indefinitely.

TABLE 16 (cont'd.)

* *Abbreviated dialing*
Commonly used lengthy numbers are replaced by two-digit numbers.

* *Intrusion signal*
A signal is automatically sent to a user if a third party comes on the line (for privacy protection).

* *Automatic call transfer*
Incoming calls to a busy station are automatically transferred to another designated station.

* *Alarm-clock calling*
Users can register in the PBX a time at which they wish to be called.

* *Paging by attendant*
When a subscriber cannot be located the attendant can page him (possibly by a radio pager). He dials his own number and is connected to the party trying to contact him.

* *Paging dialed by stations*
A paging operation can be initiated automatically by any user.

* *Do-not-disturb facility*
A user may dial a code requesting that no telephone calls be sent to him.

* *Call chaining*
When a user makes many successive calls to a remote location he is not disconnected at the end of each call so that he has to redial but is automatically transferred to the remote operator or PBX.

* *Traffic monitoring and measurement*
Traffic is continuously monitored and a manager can obtain a traffic report at any time.

* *Corporate network connections*
The PBX makes connections to a corporate network including tie lines. CCSA, foreign lines, WATS lines, and specialized common carrier facilities.

* *Priority access to corporate network facilities*
A priority structure is used so that certain subscribers are given priority access through corporate facilities and do not normally receive network busy signals.

TABLE 16 (cont'd.)

* *Facilities for interconnecting computers and terminals*
  The PBX is designated to handle data traffic, possibly from a terminal without modems. The PBX may be directly coupled to a data-processing system.

* *Data-collection facility*
  The PBX automatically scans data-collection devices and assembles the data for retransmission.

* *Contact monitoring and operation*
  The PBX automatically monitors contacts, e.g., for fire or burglar protection or for process-control applications, and may operate certain contacts.

* *Security features*
  Security provisions are provided to help ensure privacy.

Additional features with sound-recording devices

* *Prerecorded messages*
  Spoken messages can be automatically played to callers kept waiting and for other conditions.

* *Automatic telephone answering*
  When a user does not answer the PBX can play a prerecorded message from him, possibly requesting that a message be left.

* *Automatic message reception*
  Messages for a user who does not answer can be spoken to the PBX, which records them for that user.

* *Remote reading of messages*
  A user who is traveling can dial his PBX and instruct it (Using an appropriate security code) to play back the messages that have been left for him.

* *Dictation services*
  Users may dictate memos to the system, to be typed by a typing pool.

* *Reminder messages*
  Users may speak reminder messages to the system, to be played back to a given extension at a given time.

* *Music or advertising*
  Prerecorded sound is played to users who are kept waiting.

TABLE 16 (cont'd.)

Additional features which can lower telephone costs

* *Automatic restrictions on station usage*
  Each station has restrictions specified concerning what calls it may and may not make, by day and by night.

* *Facility for dialing personal calls*
  Users may dial personal calls by prefacing them with a code: the users are then billed for their personal calls.

* *Automatic minimum-cost routing on corporate networks*
  A call is routed to a number accessible via a corporate network by whatever is the cheapest route, e.g., first choice: tie line; second choice: WATS line; third choice: direct distance dialing (applicable only to calls of certain priorities).

* *Remote access for corporate network facilities*
  The corporate network may be accessed from certain telephones outside the corporation to obtain lower-cost long-distance calls.

* *Automatic monitoring of charges incurred by users*
  Charges incurred by all users are continuously monitored and may be inspected by a manager at any time. A complete listing of charges incurred can do much to reduce telephone usage.

* *External access to corporate network*
  Public telephones can use corporate tie-lines. WATS, and FX lines via the PBX.

1. It can be used most easily by anyone without special training.
2. VRS can receive information by microphones, wireless microphone, telephone, or audio circuit inputs. Using a headset type microphone, the operator's hands and eyes are free and he has mobility, which allow other tasks to be accomplished simultaneously.
3. Speech is the fastest form of human communication; therefore, the direct verbal entry method makes efficient high-speed processing possible.
4. There is no need to use the artificial coded language of the computer. The operator can use his own language and speaking style.
5. Direct input of source information increases the input speed and reliability of the total system.[146]

The VRS that is provided by Interstate Electronics is basically a clustered terminal and operates with a single-station vocabulary of 800 to 900 words or a 200-plus-word vocabulary for each of four channels. This system has a recognition accuracy of more than 99 percent. The system, through its processor, allows organized vocabulary lists for specific interactions, so that a rejection rate of 90 to 98 percent of invalid inputs, including extraneous noise, is achieved.

The Interstate Electronic terminal automatically encodes the spoken information into computer language in whatever format the host computer normally uses. With the terminal's high-level executive program and user-programmable processor, the user can

write his own applications programs without modification of the software. The operator prompting and verification feedback can be provided either visually (using the work station alphanumeric display, a CRT, or a plasma display panel) or by audio means (using a voice synthesizer and speaker).

The system is able to handle up to four user stations simultaneously, hence accommodating a number of optional features for computer interfacing, I/O peripherals, and main storage. Single or multiplexed, four-channel interfaces allow completely interactive operation with virtually any modern computer or information processing system.

Telephone capability is a significant, optional feature available with the terminal. It allows a standard telephone handset to become a direct voice link with the host computer.[147]

In the NEC Connected Speech Recognition System (VCSRS), the basic principle of the system is two-level pattern matching using dynamic programming (DP) algorithm. In the first stage, pattern matching is made between input speech and pre-stored reference patterns on word unit basis, providing optimum time-normalized similarity measure. In the second stage, the optimum word sequence is determined using DP by referring to the first stage results.

DP is a time normalization method in which the time axis of both the words in the vocabulary reference memory and the incoming speech are "warped," that is, made nonlinear, in order to achieve the best possible match in the shortest possible amount of time. The "warping" process eliminates the time difference problem

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that would formerly have prevented a proper match. In other words, the incoming speech signal from the microphone enters as an analog waveform, but is immediately converted to digital pulse code. It passes through a digital spectrum analyzer and the information generated here is compared against the vocabulary reference memory in a series of ultrahigh speed computations using DP techniques. With the data generated as a result of DP computations, a microprocessor classifies and makes the recognition decision and an interface processor then converts the decision to a form that can be transmitted to outside computers for control of machines, computers, miniprinters, floppy discs, and other peripheral equipment. The CSRS operational features include recognition of 120-word vocabulary connected speech, up to five words per spoken sentence (no pause between words necessary) with a 0.4 to 2.5 second per spoken sentence, or about 100-word vocabulary isolated utterances, on a real-time basis. The system can process two input signals independently, expandable up to four. It has an average recognition rate of 99.3 percent obtained for 4,800 utterances of Japanese, 120 railroad station names of seven speakers, and 99.6 percent of a total of 1,200 connected digits (Japanese, 2-5 digit strings) of three speakers.[148]

Bell Labs reportedly has come up with an experimental, low-cost voice recognition system. Bell says that the system could be produced commercially for as little as $300 and that it is "speaker-independent," meaning that the system would not have to be trained to recognize a given person's speech patterns.[149]

The future potential of the voice recognition systems is

bright; at present they can recognize up to 1,000 words; tomorrow, at the rate technology is moving, they will be able to recognize multiples of thousands of words.

Image Processors-Micrographics

It has been said that "pictures speak louder than words." Graphic-terminal users must find this to be true, as the graphic-terminal field is growing at a rapid rate; and the advances in random access memories have had a significant impact on the capabilities of interactive digital image processing systems. With the growing acceptance of digital image processing techniques and equipment as well as evolving imaging systems for exploitation purposes, there has been a resurgence in interest in applying these new methodologies to imagery based on film storage technology. With the advent of Computer Assisted Retrieval (CAR) that combines on-line digital data with micrographic textual or graphics information into a common system controlled and accessed through a computer, source documents or computer-generated images can be stored and accessed at speeds close to that of computer-based magnetic files.[150] Advances in telecommunication technology have the following implications for micrographics systems:

1. charts, drawings and graphics of all types as well as computer coded symbols may be digitally encoded, stored and transmitted between widely dispersed geographic locations.
2. High-digital bandwidths will permit rapid transmission either point-to-point or between many points.

3. Users will be able to take advantage of flexible tariffs to provide relatively inexpensive transmission costs at "off-peak" times such as at night when unused capacity is readily available.
4. High resolution video services will allow maintenance and creation of centralized image files which will be accessible to distributed locations.

Facsimile

Facsimile is essentially a "dot reader"--the scanner "sees" the page as a matrix that can vary from 67 x 76 "lines" or "dots" per inch to a 200 x 200 dots per inch (nearly letter quality) or even higher, if more resolution is desired--that transmits "black" or "white" as it scans the page. It is obvious why fax transmission takes so long. That is, with reasonable resolution--e.g., 100 x 100--a standard (8-1/2" x 11") fax-read page will have nearly one million bits to transmit, plus formatting, code and digital-analog-digital bits; and since most fax machines operate over 2400 bps lines, a page requires around six minutes.

It is not the speed of scanner that is slowing down the fax, but the transmission speed. Many techniques are now developed that "compress" the information ("bits"), that is, scan before it is transmitted. These techniques make transmission 10-15 times more efficient.[151]

About 90 percent of the currently available business facsimile devices are produced by five companies.

Xerox, which holds over 50 percent of the installed fax

machines, presently offers a two-minute unit to compete with sub-minute machines offered by other companies.

Qwip holds about 12 percent of the shares of fax market. They have a two- and three-minute unit presently in the market.

Graphic Sciences, which is a subsidiary of Burroughs, holds 14 percent of the market. Last year they introduced a complementary line of sub-two-minute fax units that fit into its DEXNET facsimile network.

Rapicom holds 3 percent of the market with a six-year-old Rapicom 100 fax machine, which is still dependable. Rapicom is developing a four-second fax machines that will operate at 56 Kbps. There are several others companies that provide this service, like 3M and Panafax and others.[152]

One can foresee that small business usages still will provide a market for these slow-speed systems. But the major market will be provided by large business users through a new generation of high-speed fax. According to an AM International spokesman, a system that will provide large-scale, electronic message service for business and government has been ordered by Satellite Business Systems (SBS). This system is a high-speed computerized copier system that can send exact copies of as many as 3,600 pages in one hour to a distant station via satellite and will be 120 times faster than most common facsimile devices. A fax transmission that now takes six minutes will be transacted in about eight seconds, with line charges dropping similarly from a couple of dollars a page to under 15¢.[153] The systems data capacity (1.5 million bps)

will shatter the speed limit of current facsimile systems operating over ordinary telephone lines. According to AM International Chairman, Roy L. Ash,

> Letters, business correspondence, charts, graphs, and all forms of written and printed communications will be transmitted from one point to another in seconds, instead of having to be hand delivered over a period of several days.[154]

Display Terminals

Cathnode Ray Tube (CRT) displays are so pervasive in both data-processing and word-processing applications, as well as in specialized uses, that a complete survey of the industry, even by company, would be a monumental task. Many of the uses are determined by the particular configuration (or vice versa), and capabilities are largely dependent upon software. For those reasons, we will limit the discussion to a brief outline of terminals and include a few examples.

CRT technology is best represented by the internally refreshed X-Y vector (directed beam) method or the raster scan type of operation found in television sets, in which the image is continually refreshed by each pass of the electron gun.[155] Another technology--less well-known--is the direct view storage tube (DVST), first invented by Robert H. Anderson in the 1950s. The DVST uses two electron guns and a phosphor collector plate to maintain an image on the display screen. The first gun, called the "flood-gun," sends out a broad stream of electrons (in a flood--hence the name) to strike the phosphor elements on the entire collector at a sufficiently low charge to just maintain a zero potential. The writing gun then fires a very narrow beam at the

collector target, raising the phosphor potential above luminescence. The increased charge is then held at this luminescent point by the continued operation of the flood-gun electron beam, maintaining the image.[156] The advantages are chiefly extremely good picture resolution, very low terminal cost, and lack of flicker. Overall display brightness suffers, however, and the high-use areas of the CRT may wear out sooner than with other methods.[157]

The X-Y vector method of display may be used equally well with the DVST or internally refreshed technologies. One application of the X-Y DVST is seen in the Tektronix 618 graphics display monitor for IBM 3270 systems. An IBM 3277 alphanumeric display is used in conjunction with the Tek 618 in a dual-display operation. Line drawing, coordinate transformation, geometric structures, and three-dimensional displays are handled by the combined system.[158]

Illustrative of the latest in internally refreshed technology is the Ramtek RM-9400 display generator and 1000-line color monitor, costing approximately \$50-\$60,000, which can serve either as an output device or an interactive display terminal. Flicker has been eliminated by increasing the refresh frequency; rates from twenty-five cycles per second up to sixty cycles per second are possible, depending upon the desired resolution. Zoom, pan, picture magnification, animated displays, and similar operations are possible in color or shades of gray.[159]

The cost trend in the less complicated terminal displays is promising. The IBM 2250 terminal was selling for \$80,000 in the late 1960s when Computek, Adage, and Tektronix first came out with DVST graphics terminals at \$9000-\$15,000. By 1972 the

Tektronix 4010 was available at $4000, or $.009 per bit of resovable memory. Current devices are priced at $.007 per bit, and no further down-trend is expected for the DVST displays, although the nonstorage terminals are continuing to fall in price at previous annual rates.[160]

In nongraphics, alphanumeric terminals, a wide range of programmable, "smart" terminals are available at prices upwards of $1000. The Model 10 desk-top terminal from Teleray is one example available for approximately $1300 with thirty-two programmable functions, six transmission levels, and independently programmable I/O and peripheral speeds.[161]

Lower priced units, with less capabilities, are available, and more seem to arrive all the time, but the direction for the future is not clear. Plasma gas displays and holography (not discussed here because of their relatively high cost and limited present applications) may eventually replace the raster-scan and directed beam display terminals in many applications. Internally refreshed, nonstorage displays, dependent upon microprocessor costs, are expected to become less expensive than DVST terminals after 1982.[162] What is certain is that display terminals, at affordable prices, will be available for almost any future application which can be envisioned.

Printers

John R. Pierce, formerly Executive Director, Research Communications Sciences Division for Bell Labs, has predicted a future in which "office and home terminals will mix voice and data

and pictures, or digital instructions for drawing pictures, in communicating, or in using the same lines for talking, transacting digital business and playing computerized games. . . ." Interestingly, he forsaw no difficulty in providing the capacity or the services. Rather, he states, "Cheap terminals are a greater problem."[163]

One answer is to use equipment which may interface with the home television set or with display equipment used for other purposes in the office. Highly capable printers are an alternate, or additional solution if they could be provided at reasonable cost. The prospects are apparently improving.

One such highly capable, small printer is offered by Comprint Incorporated. It's model 912, available for less than $600, is a nonimpact printer intended for small business systems, CRT hard copy, home computers, and message networks. Print quality is excellent for a printer using nonfully formed characters, and the print rate is 225 characters per second (170 full eighty-character lines each minute).[164]

Impact printing has also made recent strides with the introduction of "daisy wheel" printers and similar improvements on the IBM "Selectric" ball typewriters. One such printer, the NEC "Spinwriter" offers the capability of printing in ten languages in a single run, utilizing 128 characters on a slatted cup-shaped head and printing at fifty-five characters per second.[165]

Further up the cost scale, Wang Laboratories is now offering an intelligent image printer which combines CRT and fiber optic technology to provide extremely high resolution (90,000 dots per

square inch) with copy rates of eighteen pages per minute. The printer can accept up to twenty-four input ports, and with an additional small computer can queue multiple-printing jobs, permitting users to proceed with other work. Printers such as this make use of developments in other technologies. The Wang printer, for example, displays digitized character lines onto a CRT within the equipment where it is scanned and converted into light pulses. The pulses are read by a fiber-optic subsystem, transferred to photoreceptors and "painted" onto the paper by a light source. With copies priced at 1.5 cents per page (at quantities above the minimum monthly charge), the printer "should eliminate much of the need for office copying, as an operator can use the device to print multiple-copies faster than he can type one master and make copies from it."[166]

Although one could wish that terminal prices (display and print) would be on a declining cost curve similar to that for microprocessors, units are available at a wide range of prices for almost any purpose.

Optical Character Recognition

Optical Character Recognition (OCR) equipment, which uses optical scanning techniques to read typewritten input has been around for more than ten years. One specially designed unit was used at the 2044th Communications Group (Air Force) at the Pentagon in 1969 and later to produce paper tape from typewritten inputs for use in the high-speed AUTODIN message network. The problem with this unit, common to all early OCR equipment, was the

inflexibility. Typewritten message inputs had to be prepared with typewriters equipped with a special font, and a single error in a message frequently required re-preparation. Much of the operators' time was spent in retyping messages received from Air Force offices around the Pentagon, and the OCR was not particularly popular.

Much more flexible units are available today, although one which can read almost any font, such as the one Fairchild is developing for the U.S. Postal Service, can cost several million dollars.[167]

Even less flexible, low-cost OCR equipment, however, can generally handle several different fonts. The "EXRM Pagereader" from AM International, for example, can read ordinary Courier 12 print in addition to OCR A and OCR B fonts, in addition to the ability to ignore extraneous material such as tape, tears, and smears.[168] Another recently available, even more versatile OCR from Dest Data Corporation can read all the standard type fonts, including Prestige Elite, Letter Gothic, Courier 12, and Courier 72, without resorting to the need for any modified characters or OCR-designed fonts.[169]

The modern OCR has proven cost effective in applications such as text editing. As a test, an OCR was installed by the FCC, along with two text editors, to support two offices: the Office of Plans and Policies and the Office of Public Information. A second word-processing center was not converted to OCR use and was used for comparison purposes in the experiment, which began with installation of the OCR in October, 1977. As of early 1979, the output of the OCR-equipped center was 166 lines per hour compared with eighty-one

lines per hour in the other center. Costs per line were $.06 per line in the test center and $.09 for the comparison center, attributed to the higher productivity of the text editing equipment when used with the OCR.[170]

The rapidly falling cost of optical-character readers has made them quite competitive with other alternatives in input applications. Equipment which can recognize only specialized fonts are available for $15,000 or less.[171] The OCR used in the FCC experiment was obtained at this price, but its capability is limited to OCR-B font, and the accompanying text editor cost $18,000.[172]

Optical character recognition equipment is beginning to find applications in a wide variety of uses: input for word processing or data processing, in text editing, as the input device (and sometimes the transmission device) for telecommunications systems. The Dest Data Corporation model previously mentioned can meet these needs and provide a media conversion function as well. It can transmit data to different computers or word processors or create Telex messages through six separate output ports at speeds of 200 characters/second or more.[173]

In the future the OCR is expected to find even more applications, the replacement of many types of facsimile being one. Most transmitted materials are textual only, rather than a combination of text and graphics. And for pure text, the OCR is far more efficient, requiring only about 6000 bits to transmit a page as opposed to more than a million bits for facsimile with reasonable resolution. A hybrid OCR-Facsimile has also been proposed.[174]

Optical character recognition equipment has made considerable strides in the past decade in terms of both capability and price. Versatility is a hallmark of the newer systems, and that can be expected to increase. Without straining credibility, an OCR can be visualized as part of many work station modules within the next decade, given the continued technological advancements of the previous decade. It might be considered an ideal intermediate device on the road to a paperless system; messages received in hard copy form could be inserted into a work station slot, reviewed and edited on an associated display terminal, and directed to another destination in far less time than is consumed in a similar process today.

CHAPTER III

FOOTNOTES

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CHAPTER IV

THE SOLUTION

A. Steps Toward a Solution

The need for rapid, accurate, reliable, flexible, low-cost information systems is fairly well-established. In response, considerable technological progress has been made in recent years in media and equipment, based on dramatic breakthroughs in fiber optics, satellites, and especially in the capacity and size of computers. The question then is whether the technology is adequate to provide a solution to those needs. If so, how? And when?

In the view of many experts, the technology is already well-enough advanced that the only remaining task is to apply it. James H. Bair of SRI International has stated, for example, that:

> . . . the evolution of technology to support communications is *fait accompli,* and the proposition that it is cost-effective is encouraging.[1]

Of course, the intent is to indicate that the application of the technology is cost effective. Thus far, however, assertions such as Mr. Bair's are based on fairly limited data, largely from the experience of the nation's large corporations, and government. We are only beginning to see applications of the new technology as a fairly wide-spread phenomenon in the medium and smaller businesses which comprise the vast majority of America's enterprises. The

former Chairman of AT&T, John D. deButts, is one who feels that the technology holds great promise, if applied. He has stated:

> We are, I believe, only beginning to sense,--much less exploit--the potential for improved productivity that resides in information technology.[2]

Leonard Kleinrock, Professor of Computer Science at the University of California, is another who is convinced that the technology is already being applied, at least in computer communications, and that significant change is already clear. He says:

> A revolution is in the making! We are witnessing a growth rate in technological change which is overwhelming. Thanks to enormous advances in data communications and in integrated chip technology, we are in the midst of a computer communications explosion which has already made significant changes. . . .[3]

Kleinrock goes on to anticipate the second phase of this revolution, the "widespread acceptance and application of teleprocessing and networking by the business sector of our economy."[4]

Mr. deButts, at least in his 1978 report to shareholders, would appear to agree. In his words, "At last, the Information Age, so long heralded, so long deferred, is here."[5], which contrasts somewhat with a view he had expressed only a few months earlier:

> Casting my mind back 20 to 25 years to the predictions that were then current that the computer would lift from mankind those vestiges of work of which the Industrial Revolution had not already relieved him, or that it would drain society of all humanity, I cannot help but wonder what the fuss was all about.[6]

At the more pessimistic extreme, Professor James Driscoll, expressing his evaluation from a behavioral science perspective, has come to the conclusion that the "prognosis is bleak" for utilizing the new technology to increase the productivity of our white collar workforce through automation."[7] In his analysis he

sees a requirement for "a comprehensive review of the behavioral implications of this technology," without which "the returns to investment will continue to be marginal at best."[8]

Professor Driscoll, however, appears to be in a very small minority in assessing the potential for applying technology to solving management's information needs, intra-office, inter-office, and inter-organizational. Professor Driscoll himself offers examples of how the new technology can be made to provide highly successful solutions if the office is redesigned to include "new approaches to decision, communication, task design, leadership, and human resource development.[9]

Generally, a survey of the current literature finds that those who have studied the prospects for improved information systems are impressed with recent progress and quite optimistic about the future. They would tend to agree with the assessment by the Chairman of the Federal Communications Commission, Charles Ferris, that "The technology is way ahead of the marketplace." and that "We are at the crossroads of the information society."[10]

Still, even among those who agree that the technology can be applied to solve society's information needs, there is considerable room for disagreement about the time frame involved in which the "information society" arrives, or has already arrived. Probably the best assessment is that we are involved already in an information society, with the majority of our workers employed in positions related to a broad definition of information products or services. Indeed, the "information revolution" or "telecommunications revolution," the "information explosion,"--all these simply describe

a rapid increase in the rate of change in an evolution of information technology that stretches back at least to the development of the telephone in 1876. In the sense that it is an evolution of information technology with which we must deal, rather than any sudden "explosion," the perspective of change becomes less overwhelming.

The concept of an evolution in the technology, rather than a revolution, is quite important. If we are undergoing a revolution, the intelligent thing to do is to wait until we see what replaces the current information systems, and then we adopt the new systems, because a revolution replaces the old with the new and stability follows. Such is not the case with telecommunications. The old is being replaced it is true, but on an almost continual basis, without stability. This is evolution, and the only constant is a continuation of the change. There is no sudden, single event or combination of events with which, like any problem, we can deal, and then move on to other more pressing problems. The "revolution" of which so many are speaking will still be a "revolution" in 1985, in 1990, and out to the end of this century, as technology, equipment, media, and applications continue to evolve.

Within this long evolutionary process, changes have occurred at different rates; currently the rate of change is so rapid that the visionary projections of even a few years ago have understated the process. One of the most current and most quoted texts on communications and computers is James Martin's Telecommunications and the Computer. This superbly written book, quoted earlier,

was published in 1976, and among the "futuristic" projections it contained was one for prices of microprocessors to fall to "less than ten dollars," in "an era when it will cost less to buy a microprocessor than to fill your car with gasoline."[11] In volume purchases, as this is written, microprocessors can be obtained for prices between one and two dollars apiece,[12] and a price comparison with a gallon of gasoline would be more appropriate than with a tankfull.

The next question is whether this rate of technological change is matched by an equivalent rate of change in applications. The evidence, in circuit usage and telecommunications equipment sales, appears to provide a solidly affirmative answer, and the reasons for this sudden acceleration can perhaps be explained by the following:

a. The imitative factor

b. The threshold factor

c. The cost crossover factor

d. The absolute/relative factor

The imitative factor simply relies on an emulation of the successful pioneers by the more cautious users. The success of the implementation of an advanced system by Buford Smith, then Director of Telecommunications, for Cook Industries has been cited as one pioneering example.[13] The Texas Instruments TICOG network, and the Hewlett Packard COMSYS are two others. Even earlier than these, the Department of Defense and other governmental agencies had successfully established computer-based message systems and word-processing capability. In the early 1970s, for example, the

National Security Agency (NSA) was using Univac CPUs, Honeywell DDP-124 communications handlers, and specially designed "smart" CDC display terminals (replaced with Digital Equipment Corporation PDP-10 and PDP-11 equipment at the end of 1973) to process incoming messages from various sources. The messages could be displayed, edited, stored, retransmitted, or output into hard copy by high speed printer or Selectric typewriter. Messages by copy or series could be extracted from memory for display, and the terminals could be used to communicate among positions.[14] Successes such as these have led others to follow, or, at least, to the desire to follow.

The threshold factor, as explained by Kalba Bowen Associates,[15] involves increasing acceptance of a new communication mode and also the increased value of a system when multiple users are brought into it. The acceptance may arise simply from familiarity. If several members of a community are using a new method or system, the new communication mode will gradually lose its "strangeness" and acquire acceptability among the other community members. As more transmitters and receivers of this community join the system, the utility of the system increases for each user. As this threshold level is passed, terminal prices, service prices, media costs, may all fall sharply, accelerating the rate of penetration.

The cost crossover factor refers to the point on a chart at which the rising cost of one product or service intersects the falling cost line of a substitute product or service. That point may be quite difficult to determine; in fact, however, all that is necessary is a perception that such a crossover has occurred to

induce a substitution of the original product with the alternative. In telecommunications there are several such crossover points. One such point may be perceived in the rising costs of mail compared with the alternative of sending message traffic via the common carriers or compared with the cost of a short telephone call. For larger companies, the comparison may be the aggregate cost of mail and public network message services against the unit message cost of establishing a private network. Another crossover point involves the rising cost of office personnel salaries, averaging a 6 percent annual gain, against the costs of communications and computer logic, which are dropping annually by 11 percent and 25 percent respectively.[16] It is more difficult to define still another crossover point--that between rising travel costs and falling communications costs since travel is so affected by changes in energy costs, a process in a state of change as this is written. But the perception of rapidly rising costs of travel, as well as possible inconvenience, in comparison with falling communications costs, may induce substitution of a communications option for the travel option even before travel costs in a more stable environment can be calculated. Similar crossover points are occurring with other products, such as paper costs, as might be expected in an inflationary environment. As the crossover point is reached, and then exceeded, the realization of its occurrence, simultaneously, by many users may cause something akin to a stampede in the desire to acquire the now more cost-effective alternatives. The beginning of this movement in telecommunications equipment and services could easily be interpreted by an observer as evidence of an "information explosion" or

"telecommunications revolution."

Less dramatic, but still important to the acceleration of change in telecommunications is the absolute/relative factor. Computer costs are perhaps the best example. While computer costs have been falling dramatically from year to year there may be a tendency on the part of the user to "wait a little longer" before committing himself to a purchase involving several hundred thousand dollars--something better, at less cost, will be announced in a short time, and so long as the expense is a large one, this *relative* cost advantage may loom large in the user's decision. As the same capacity becomes available for a couple of thousand dollars, the advantage in waiting is far less clear, even though the relative cost trend is still downward at the same rate as previously. The absolute dollar amount involved has become far less significant. If the capability of an IBM mainframe becomes available in 1984, as has been predicted, for a price of $100,[17] the decision to purchase the same capability for a price of $200 or $300 in 1983 would be far less affected by a relative cost savings of 50 to 67 percent than was the case when the absolute dollar amounts were much larger.

These four factors can explain much of the acceleration previously discussed; the availability of products or services (digital networks, for example), and the reduction in the regulatory barriers are two other elements affecting the rate of change, but they tend to be more effects of change than causative factors. That is, they tend to lag the changes in demand rather than lead it.

With the reasons for the apparent "revolution" in communications explained, there remain the questions of the significance

of this rapidly changing environment, and what the appropriate reaction to it should be.

Daniel Bell, Chairman of the Academy of Sciences Commission on the Year 2000, explains that communications is one the three infrastructures which tie society together (transportation and energy grids being the other two), and the "revolution in communications makes it likely that there will be a major shift in the relative importance of the infrastructures: communications will be the central infrastructure. . . ." We are, he asserts, moving into a "post-industrial society" in which "knowledge and information become the strategic and transforming resources of the society, just as capital and labor have been the strategic and transforming resources of the industrial society."[18] If we accept Bell's explanation, the significance of the acceleration in information is unmistakable--failure to accept, invest, and implement systems for information handling in the information society will have an impact and results quite similar to the results of failure to invest in capital equipment or labor in the industrial society.

What reaction is then appropriate becomes the critical question for the executive who understands the significance of these changes. If he rushes out to buy an "office of the future" or an "electronic mail" service, thinking this will solve his problem, the office manager is almost certainly doomed to failure. This action would duplicate the error in thinking which treated the rapid evolution in telecommunications technology as an instant revolution. And just as the change is not instantaneous, neither will the solution be. As Michael Zisman of MIT points out, while

technology has provided an *opportunity*, the rate at which this technology will be integrated into most organizations will not be revolutionary at all."[19] And office automation itself, if that were the goal, "is a process rather than a product,"[20] explains a recent Frost and Sullivan seminar.

It is the contention of the authors of this paper that neither office automation nor any of the various "electronic mail" services represent the long-term goal which should be sought. Rather, it should be a plan, a concept for a "Telecommunications Information System (TIS),[21] or a "Total Information System," that would include office automation and electronic message services as parts of a more comprehensive, longer-range telecommunications plan to accommodate the changes which have occurred and the changes still to come.

B. The Telecommunications Information System

A Telecommunications Information System (TIS), to meet the objectives which we envision, would have a variety of characteristics. The objectives include speed, accuracy, reliability, responsiveness, multifunctionality, user-orientation, transparency, flexibility, low-cost, and the capability for evolution. To meet these objectives the TIS must be entirely digital, computer-based with distributed intelligence, integrated and system oriented, modular, system-complex but user-simple, and shared-use.

There is no one for one correlation between each objective and a characteristic. Table 17 lists the objectives and the most important characteristics of the system which will facilitate

TABLE 17

TIS OBJECTIVES AND CHARACTERISTICS

Objectives	Characteristics
Speed	Computer-based, wideband, digital
Accuracy	Computer-based, error-correcting, digital
Reliability	Redundant, multipath, distributed, computers-based
Responsiveness	Interactive, on-line, high-capacity, digital, computer-based
Evolutionary	Modular, high-capacity, expandable, computer-based
Multifunctionality	Integrated, process-oriented, system-oriented, system-complex, user-simple, interactive, computer-based, digital
"Friendly" user-orientation	System-complex, user-simple, interactive, computer-based
Transparency	Network intelligence, system-complex, computer-based, digital
Flexibility	Modular, computer-based, digital
Low-cost	Wide-band, high-capacity, integrated, modular, expandable, system-complex, distributed, computer-based, digital

attainment of the objective. Some of the characteristic pertain to those portions of TIS which would be located at the subscriber premises while others would be characteristics of the network; some would apply to both. The following will explain in more detail the rationale behind the characteristics in relation to each objective.

Speed

The computer alone is able to control the transmission of information at the rates required for TIS. The quantity of information to be transferred efficiently and at low cost requires that all facets of the system itself be digital. High data rates with a digital system make a very wide bandwidth imperative

Accuracy

Error-correcting methods must be applied to insure accuracy of the information transmitted. Error-correction methods can be applied only with digital techniques, and the complex methods used require the high speed manipulation capability which only the computer can provide.

Reliability

To insure transmission from point-to-point, redundancy of equipment and redundancy of paths or media are required. Control of the complicated switching through these redundant equipment and paths can be accomplished only through the computer.

Responsiveness

The system should be on-line and ready for service without lengthy preparation, as is the telephone. It should be interactive, providing information on status (and not simply shutting down in response to a human input error). It should have the capacity to handle large quantities of data and not require the user to spend needless idle time waiting for the system to "catch up." These requirements necessitate that the functions be computer-based and digital.

Evolutionary

The TIS should accommodate state-of-the art changes which improve capabilities without changing the system itself. This requires modularity of the component hardware architecture as well as a large initial capacity. This capacity must also be expandable without extensive change to the system itself. Again, these characteristics require a computer-based system.

Multifunctionality

Multifunctionality demands several characteristics, the first of which is integration of functions and services and sources into single locations (rather than separate locations for each, as is the case of a switching function at one location, word processing at another, an incoming message center, a distant data-processing center with its own network, and so forth). The system must relate each task station to the process in which it is involved, and that process must relate to the overall system comprising many such processes. Such a multifunctional system could prove impossible

to use unless the complexity is built into the system itself while remaining invisible to the user. The computer is required.

"Friendly," User-Orientation

A TIS should not demand high technical knowledge from the user, nor should it be intimidating. Functions should be simple and easily performed to obtain desired results. Nor should the system appear as a "blank wall" to the user; what is required should be obvious, or should be indicated after simple inquiry, through an interactive process. This again requires system complexity, possible only through use of a computer.

Transparency

The user should be aware only of action and reactions in the system. A destination across the continent should be a simple address, no different than an address across the room or across the hall. Complexities such as protocols, standards, and circuits should be of no more interest than the complex switching of the present public switched (telephone) network would be to a grandmother calling her grandson. This again requires that the complexity of TIS be included within the network and/or the local system. Only the computer can handle this complexity.

Flexibility

Functions may vary over time, and the system must be capable of adapting, either through a simple software change in the computer or through replacement of one of the system modules without affecting the operation of the balance of the system. Ideally the switch in function should take place from a workstation itself without

reloading and reconfiguration. An all digital system will facilitate required change.

Low-Cost

Cost savings from TIS will come chiefly in two areas--the reduction in the cost of information transfer and a reduction in human time involved in the process. In networks this will mean shared use of a wide-band, digital, high capacity, intelligent transmission system. Locally TIS should be integrated, computer-based, modular, expandable, with system complexity hidden from the user. Finally, the major cost savings will come from achievement of the other objectives listed above, since each will contribute to a fast and reliable system which does not require labor-intensive activities for accomplishment of required tasks.

This list of objectives and characteristics can provide a guide to avoidance of some potentially expensive or inefficient choices in planning for future telecommunications needs as well as an indicator of desirable characteristics.

For example, a conventional PBX might not fit well into business plans for an integrated, all-digital system, and delaying the purchase until a switch fully capable of handling digital data directly might prove more advantageous. This is not to say that a switch which can otherwise be cost justified should be put off.

The purchase of stand-alone terminals or word processors without built-in intelligence and a communications capability could prove equally inefficient and eventually expensive when a more fully integrated system is desired. This might be especially true for the

small but growing business which wished to expand its telecommunications system at a later date.

Single services, such as an end-to-end facsimile service, may prove to be equally expensive, and redundant, if a later decision is made to obtain multifunctional services from an intelligent network carrier. Some of the highly touted "electronic mail" services may be undesirable if the equipment cannot be integrated with a more complete system at a later date.

Analog equipment and services based on analog circuitry should begin to be avoided over the next few years as digital circuits are phased in on the public switched network and as all-digital specialized common carriers broaden their offerings. Equipment which is not cost effective with a three-to-five year depreciation schedule will likely become an obsolete millstone unless an alternate use can be planned at the end of its technological obsolescence.

Similar caveats will occur to the telecommunications professional who concurs in the inevitability of totally integrated, digital systems developing relatively rapidly. (See the Appendix for a view that such systems will be available by the mid-1980s).

But, in the final analysis, it is not hardware or systems which solve problems--people solve problems. The most sophisticated equipment, even a fully mature TIS, can serve as nothing more than a tool for people who know how to use them in the solution of problems. For that reason, the sections which follow, dealing with some of the implications of a TIS implementation, will put heavy

emphasis on the humans and their organizational systems which in the end will determine whether TIS will, or can be a success.

C. The Stages of TIS

Just as with the "Office of the Future," a fully mature Telecommunications Information System (TIS) is not around the next corner. It will not happen instantaneously or to the same extent in all organizationa. The complexities involved in a true TIS are enormous, and will require the efforts of representatives from the behavioral fields as much as from the technical fields. And while the goal of a TIS can be set immediately, the process "cannot be a social revolution, it has to be an evolution.[22] A TIS, which incorporates the idea of an "automated office," will involve the same problems which observers have been analyzing for that concept. For that reason, using the words of Evelyn Beregin, President of Reaction Corporation, "It will be a long time--it always takes longer than we expect to change the way people customarily do their business."[23]

Office automation, the truly "automated office," as Michael Zisman has stated, will "depend on our ability to incorporate the notion of process into our systems thinking."[24] Research analysts Frost and Sullivan agree; they believe that automation of the office "should be looked upon as a process--implemented at various stages--using products."[25] It would be useful, in establishing the goal of a TIS, to hypothesize what these stages might be and the time frame in which they will be realized. A survey of the thinking on this subject has provided a consensus which proves useful in

planning for the process. Implementation of a TIS would consist of:

1) An initiation stage
2) An expansion stage
3) A formalization stage, and
4) A maturity stage

Stage One

The first stage, initiation, is the mechanization of tasks, with telecommunications and data processing functions separated. The telephone is the basic telecommunications instrument, and the public networks and services may be used on an occasional basis as a supplement. Within the office, the "Emphasis will be on the more efficient production of paper, as opposed to the longer range objective of reducing paperwork."[26] This is the point at which most offices are today. Word-processing systems have dealt exclusively with clerical tasks where a small percentage of costs and improvement are possible. Word processing is on the market to decrease the typing function of a secretary. Systems are purchased after it can be shown that secretarial costs will decrease. Rarely do you hear of a system being implemented to give management a larger span of control due to larger amounts of information at his fingertips.

Automatic identification of telephone calls is another of the tasks that has been mechanized. Private branch exchange (PBX) vendors have come out with this feature within the last five years. Here the manager receives an itemized list of calls placed within his department for a given time period. This list then has to be

processed according to the individual organization's needs. The end result for this innovation is more paper. The initial reports and those processed have generated additional paper--not a step backward, actually, because information has been processed to some extent, but a step in the wrong direction.

The technology at this stage will be implemented primarily by a facilities manager. The person who is in charge of purchasing stationary and keeping the grounds kept, will also have the responsibility of implementing these technologies. It will not be until the second stage, when the organization will realize the need for technology to keep abreast of change and will initiate a telecommunications department. Most U.S. corporations will have passed through stage one and onto stage two by 1983.

Stage Two

The second stage, the stage in which expansion occurs, will produce a multitude of different types of mechanized office equipment. This is what people conceive as "office automation" or the "future office." Nowlan states that "a more accurate term (for this period) would be office mechanization."[27] The main principle will be to reduce and speed up the amount and flow of paper by the use of electronic message systems. Tasks will be mechanized to provide management with additional tools. Nowlan suggests that "we will mechanize tasks that people perform (e.g., typing, filing) but not automate the functions that they perform."[28] (i.e., office procedures)

Some organizations seem to be planning for this stage as a final goal, seeking to install "electronic mail" services in support

of a more mechanized office, but these organizations will have an opportunity to move on into the more advanced stages of TIS along with those who have established longer range goals, since TIS will necessarily be hardware-independent and capable of assimilating the products installed to satisfy lesser objectives.

It is in this stage that organizational and human factors will begin to play a much larger role. Technology will no longer be the crucial factor (and it will continue to play a lesser and lesser role). If management fails to take into account both the organizational and human implications at this stage, the system will not be effectively utilized and the possibility of increased organizational conflict (turnover rates, job dissatisfaction, etc.) could well negate the advantages gained.

Stage Three

The third stage will formalize the continuing process, and it will be management's responsibility to see that the process itself is automated. According to Howard Nowlan, this stage "will focus on what is being done in the office in addition to the tools used in the office to carry out office tasks."[29] "The critical part of the analysis is the construction of models of the individual manager's tasks and communication structure."[30] This is necessary in order to get the procedure down on paper. "Although there is an almost regular pattern in the workload of a typical office, events occur over such a long period that the patterns are hard to identify."[31]

This stage will see the initiating control sources shift from man to computer. Thus, we will have finally started to relieve management of some of their unnecessary and costly decisions. The system will now provide two main functions--it will "integrate applications and facilities more cohesively, and will shift from mechanizing devices more towards automating processes and from mechanizing tasks to automating functions."[32]

It will be at this stage that TIS will facilitate organizational goals. As stated previously, there are some corporations which will reach this stage before others. The innovators who do keep attuned to new technology applications will begin this stage somewhere around 1985. It will not be until 1995 that the majority of organizations will come around to stage three.

The human element will now play a more significant role in comparison to technology. Technology will have advanced us much farther into the "Computer Age." For this reason a later section deals more fully with the human and organizational implications of a TIS system.

Stage Four

The last stage, maturity, will see the continued integration of additional procedures and facilities within the office. Others will be de-automated as it will be found that the human element is still needed. "As the automativity increases, integration of function increases."[33] It is here where the development of knowledge based systems will be completed.

Maturity will not take place until 2000. This is when the

majority of organizations will be reaching this stage. The front runners are thinking in these terms today and it might well continue for a while, as manufacturers and service companies have not come close to devising such a system for use. "The various applications are not being re-examined and integrated into systems which link people, devices and procedures into structures which take advantage of the best features of each."[34] It will take at least fifteen years for this to be accomplished--less time than it took the computer, but nevertheless not overnight like the calculator.

D. TIS and the Organizational Process

The TIS system as introduced is a concept which is applicable by the small, as well as the large, organization. True the wide range of technological applications which have been discussed will not be entirely utilized by the small organization. But as has already been seen earlier, a one-man office can make such effective use of the new technology already available that costs can be reduced significantly while greatly expanding output. With the rapidly falling cost of hardware, even the smallest company can expect to make more and more use of new communications options as a variety of new products and services are supplied to the market at increasingly affordable prices over the coming decade. For the small company which is expanding, organizing to cope with ever increasing information needs is equally as imperative as for the larger company. And since the techniques and equipment which will serve him will have the same characteristics as those serving the larger user, the concept of a Total Information System, integrated, computer-based,

and digital, will prove as useful to the small organization as to the large.

The scope of planning for changes in the organizational process, however, will be much greater, and far more complex, for the large organization than the small. For that reason, the factors which address human needs, organizational change, and management decision support systems, which follow, will be of greater significance to the medium and large organization than to the small.

There are three considerations in properly diagnosing the organization and its procedures. The three are:

1. Utilizing human resources
2. Organizational change, including job redesign
3. Evaluating management decision support systems

Utilizing Human Resources

Mechanization of the office has often created a bloodbath with employees and office managers alike. Michigan Consolidated Gas Company of Detroit almost became one such fatality. Stephen E. Ewing, Vice-President of Personnel explained,

> When we had made the decision on word processing, we had to create a whole new organization. Originally, we approached the concept on the basis of equipment, but it was not long before we realized that we had to concentrate on people. Our turnover was high, and so we not only had to structure the organization, but we also had to stabilize our support personnel.[35]

Carol Solai was the manager of Michigan Consolidated Gas Company's office systems. She was responsible for the activities of,

> . . . over 300 employees with a 6.5 million budget in the areas of word processing, graphics and reprographics, PBX, mailing,

> corporate records, training, budget planning and administration services, information retrieval, records and storage systems and systems and programs, all headed by a managerial and supervisory team under her direction.[36]

Ms. Solai became Modern Office Procedures, 1979 WP executive of the year.

> Her approach embodies a problem-solving combination of career path development and job enrichment through testing and career counseling, job related educational courses at local community colleges and universities (company paid), performance reviews, and merit ratings, and on-the-job training and career development.[37]

The efforts of Ms. Solai paid off. Among her achievements she:

* reduced employee turnover from 50% to 15% by providing a career path for her subordinates.
* produced tangible cost avoidance savings of over 1 million dollars.
* drastically cut the turnaround time on documents from one to two days to under an average of four hours.
* developed a graphics department which has produced a concrete savings of over $150,000 over and above the initial cost of equipment.[38]

The above was cited to show that an effective human resource development program should not be overlooked. This aspect of person-to-person assessment should not be overlooked as the computer becomes more of a part of our society. As TIS systems become more individualized, the organization will have to take on more responsibility in education. Erv Stedman, President of the International Word Processing Association states that,

> The company that does not train and keep its people at all levels advised of new management skills and techniques is going to fall behind. Human relations in in-house training . . . are particulary important-people's lives and the way they have been doing their jobs are changing.[39]

Professor Driscoll of MIT states that "A careful career counseling effort should match those interested in more responsibility with jobs containing such opportunity."[40] Carol Solai did just that. She,

> used an assessment canter to select the 38 supervisory and management personnel reporting with the structure, implemented a grading system, complete with new job descriptions and career paths for all word processing personnel including comprehensive training, job counseling, educational courses for career path enhancement.[41]

The majority of productive organizations have paid careful attention to their human resource policies. Productive systems have a few similar characteristics. They include:

1. Few rather than many distinctions in status among members.

2. Reward systems, like pay and promotion, that reflect actual task and decision responsibility rather than the descriptive characteristics of the workers such as sex of formal education.

3. Career paths formalized so that workers can look forward to predictable advancement in the organization. Alternative career paths are provided for those who are looking for different opportunities. "Individual needs are identified by a process of career counseling and matched with the demands of an organization by means of selection, promotion and transfer policies."[42]

At this point the need for a good communications department within the organization should be emphasized. If there is no such department then it would be wise to consider an outside consultant.

> Outside consultants usually have, as their principal value, the authority and commission to cross organization boundaries which are, too often, barriers to communications and co-operation. Consultants are also able to probe down deeply through the levels of the organizational structure which tend to insulate upper management from the knowledge workers. What often happens is that the consultant, unimpeded by organizational barriers, serves to uncover and define the lode of expertise that is latent within the organization. The outside consultant can see organizational communication problems sometimes more easily than the in-house manager.[43]

As Mr. Pugh of Lexitron recently stated, "And few companies have the internal expertise to understand a paperwork system."[44] Due to people's inherent nature to react negatively or suspiciously to change, the full implementation of TIS will take longer to complete. People, when faced with the implementation of a computer-based system, will become afraid that they will be put out of a job. Resistance is a negative/defense reaction inherent in everyone. William F. Laughlin, Vice-President of IBM's Office Products Division, when speaking about the limiting growth factor in future systems, stated that, ". . . it will be the willingness of people to make changes to their offices."[45]

Some of the individual modules in future TIS systems will be based upon equipment similar to today's communicating-word processors or data-transfer terminals. For that reason some of the particular problems associated with implementing a data-transfer terminal will be discussed. There are some factors to consider which will increase human efficiencies. These factors include:

1. User acceptance of the introduction of interactive terminals.
2. System response time
3. User response to key board format

4. Communications language. Heavily data processing (DP) oriented languages are difficult for users without a DP background. This will change as educational and training institutions give instruction on the use of data transfer equipment as part of their curriculum, including languages to the extent they are still required.

5. Suspicion of network fragility. Users feel (and with some systems it's true) that by pushing the wrong button, they will cause harm to the system or program.

6. Error handling and error messages provided by the system.

7. User reaction to the network or terminal environment.[46]

In a 1970 study entitled "On the On-Line User of Remote Access Retrieval Services," author R. V. Katter revealed four reactions that neophyte users may experience at a DP terminal. They are as follows:

1. Pressure Reaction. Due to the rapid response time of an interactive system, the operator may not allow adequate time to fully interpret system feedback, resulting in hurried decisions and a suboptimised search interaction.

2. Peephole effect. Terminal users are only allowed to see a small percent of the information they are interacting with. This is more prevalent with keyboard send receive (KSR) terminals as they have no screen for the user to look at.

3. Fishbowl effect. This is concerned with the inhibition of people to let the general office workers see how well they interact with the terminal. Also it lets others see what the operator is working on.

4. Lack of sympathy effect. This is concerned with the lack of personalization. ". . . the data terminal may express concerns and interests of persons who do not share the user's

personal views, values, or goals.[47]

Katter states that the four effects, when combined, will create a role reversal between the operator and the terminal. Instead of the operator dictating to the terminal, the overpowering effect of the computer creates the role reversal. Hopefully, these effects will be mitigated, or eliminated, in the more human-oriented, "friendly" terminals of future systems such as TIS.

When installing systems which greatly increase the process of information transfer, management should anticipate the possibility that certain disbenefits, as well as benefits, may result. If sufficient attention is not paid to the processes involved, in addition to the specific functions for which applications are sought, instabilities may inadvertently be built into the new systems. Frank S. Barnes, Chairman of the Electrical Engineering Department at the University of Colorado, has warned that "Different processes have different time scales," and if the time scale is not taken into account, instability could occur.[48]

One example of such instability results from the information feedback which engineering students receive from the job market when they are planning their college enrollment. If industry is encountering a severe shortage of engineers as the new students enroll, a much larger number will choose an engineering career than might otherwise be the case. The same might be true the following year, as additional students select engineering over alternative careers. The massive enrollment creates something of a "hump" in population of engineering students, and if the

engineering job market has stabilized during the four years of the education process, this "hump" can greatly destabilize the job market when an exceptionally large number of graduates compete for the relatively fewer available positions. The excess of engineers in the job market then becomes feedback to new students who are selecting a career, and in this case they are dissuaded from choosing engineering. Four years later the job market is faced with a large shortage of engineers again, and the cycle repeats.

In the case cited, the time scale has not been matched to the process, and the information transfer system is inappropriate for the needs of both students and industry. The "oscillation effect" in the engineering job market can largely be attributed to the fact that the student-decision process is affected by the immediate information at hand--a shortage or excess of engineers--when they actually should be basing such decisions on the prospects in the job market of four years into the future.[49]

One can hypothesize situations in which the oscillation effect might similarly affect financial or industrial processes. If, for example, one has established a system to withdraw parts from inventory for production, in which the parts are actually moved to the production line several days, or even weeks, later, a problem can arise in ordering replacement parts if the ordering function is not integrated with the flow of parts to the manufacturing floor. A physical sampling of inventory would reveal an ample supply of the desired components, and no order would be placed. Days later, as the parts moved to the manufacturing floor, and new

production scheduled, an analysis of the production scheduling records would show a severe shortage of parts and perhaps cause management to direct an additional order at the same time that a normal replacement order went out, resulting in an excess inventory of that part when the orders arrived. The same excess could result if management compared projected parts' requirements for the original order against a physical, present count of parts in inventory. An order might be placed for additional parts in spite of the fact that a previously placed order might arrive well before the production process required them. The solution would be to integrate the production system and the inventory system so that present needs would be matched against present inventory and future needs would be matched against future inventory, thus avoiding the instability inherent in failing to match the time scales of both systems to the process involved.

Another problem besides the oscillation effect with installation of an extremely rapid information-transfer system might result from elimination of bottlenecks. If the bottleneck had served a positive function in the old system, by measuring out the flow of information to which an employee was required to react, the elimination of that bottleneck might cause instability. One can visualize an employee being deluged with an "information overload," in which so much information was provided in a relatively short time that he could not cope with it. Here, the instability might result in no decisions at all rather than an orderly series of decisions in reaction to the orderly, measured presentation of information. Management then would have to go back and build

"bottlenecks" into the system.

Management should be aware, then, that an almost instantaneous information transfer system may prove to be a mixed blessing, and prepare in advance for potential instabilities such as the oscillation effect or bottleneck effect.

Apathy Towards Typing

There is also the inherent problem that the office of the future will (in the short run) necessitate a great deal of typing. There are three reasons for peoples' apathy towards typing. They include:

1. Dislike--they abhor the mundane task.
2. Poor typist--never being trained, the operator continually makes mistakes (more competent secretaries would normally perform this task).
3. Beneath their dignity--many managerial people due to stereotyping consider typing a subliminal task.

This section has dealt this the social and humanistic aspect of TIS. Management has had the opportunity to learn from others' mistakes. Many corporations have not looked at the humanistic side and have made costly mistakes. "Y & R's (Young and Rubicom) biggest mistake was in human relations. . . ."[50] McGraw-Hill had a goal to reduce the number of its secretaries. "Instead, nobody used the system."[51] A word-processing system was installed from 1967 to 1970 when it called it quits to the $80,000/year project.

"Automation will only perpetuate existing inefficiencies in the office and true increases in productivity will come only from organizational diagnosis and design of office work."[52]

As stated previously there were three steps in organizational diagnosis: human resources, job redesign and evaluating management support systems. The latter two are also of importance in implementing a TIS.

Job redesign is concerned with the evaluation of each job function as it applies to the organization. Many times higher management can be relieved by delegating some of their tasks to lower management. A redistribution of work could well save more than the installation of one of these "new fangled telecommunications devices." Presently the innovative competitive organizations are accomplishing this through participative policies. Management, their subordinates and representatives of all affected parties would all discuss the work and agree on the redistribution. According to Professors Lawrence K. Williams and Thomas Lodohl at Cornell, "The results of this approach have been increased efficiencies."[53] As Mr. Silver of Hendrix points out ". . . the best way to take advantage of new technology is to be sensitive to the needs of office personnel and to involve them in decisions about equipment and implementations.[54]

In addition to job redesign there are three other implications of implementing this technology which the manager should be concerned with. They are:

1. Reduction in informal communications channels
2. Social task considerations
3. Implications on leadership

New equipment almost invariable reduces the existing informal communications channels. Informal communication in an organization

is important in that it provides the manager for a means of conflict resolution, personal contact and political negotiations. As "technology becomes more complex and as markets become more interdependent, scholars have found the need for more and more informal, face-to-face contact within organizations to maintain effectiveness and productivity."[55]

As we have seen there is a need for task design. But in addition to the redesignation of tasks, there are social tasks which must be performed. Group meetings allow the participants to "identify common goals, determine which roles the individuals will play in a particular work group, and to resolve conflicts in authority."[56] Thus, more and more informal meetings would alleviate this problem.

Another aspect of organizational design that should be looked at is leadership. Leadership provides a healthy social work environment. ". . . without social leadership, not only will organizational members tend to withdraw from the organization but conflict and friction will interfere with task performance.[57] One important aspect is the female worker who is usually the word-processing operator. Today's females are increasingly disenchanted with their work. The increased female membership in unions is directly attributed to this.

In regards to evaluating management-decision support systems, the existing and future needs of managers to have access to large amounts of information has been cited in Chapter I. Professor James W. Driscoll pointed out this need when he commented that "Some procedures can be routinized, but more importantly the need

for information support systems for higher level workers engaged in discretionary tasks will become obvious."[58] Data processing will play an important role in TIS. Large amounts of information must and can be at the manager's fingertips. Office managers will not be able to afford to let this valuable tool go unused.

Today's decision-making strategy uses the concept of decentralization of decision. Decisions in the optimum situation are made by the person who is closest to the problem to be solved. With the TIS system any one of a number of managers are "right there," as the systems transparency hides the separation of distance.

> A decentralized, flexible approach to decision making stands in stark contrast to the rigid lines of authority imposed on most office work. Until this decision structure is loosened up to fit more accurately the natural demands facing in an office, then no infusion of new equipment can increase that social system's productivity.[59]

As Frost and Sullivan point out ". . . the ultimate payoff is likely to be in providing better control over the tasks for which they [management] are directly responsible."[60]

E. Approaches In Implementing TIS

Whatever approach is used in implementing a Telecommunications Information System, it is absolutely essential that top management be fully involved. If they are not involved, the result could be a "blood bath."[61] This assessment has been made based upon experience with previous attempts to install more advanced or more automated systems, and it could become more of a reality as the attempt is made to move to still more comprehensive systems such as the proposed TIS.

One reason it is vitally important that top management support be received is that the whole organization will be affected by TIS, including both processes and people. In order to use the technologies involved in such a system, changes will be unavoidably forced upon the organization which will not be made without the full backing and support of management. As Carlisle has pointed out, "It is not the introduction or development of communications technologies *per se* which will lead to improvements in the office, but a supportive managerial climate and careful planning that can put them to good use."[62]

Another reason for top management involvement is the need for a full financial commitment based upon a genuine acceptance and demonstrated value for automation within the executive suite itself. Without this acceptance, financial support may well be inadequate, and inadequate financing could well short-circuit the best-intentioned plans to acquire and implement the new technologies.[63]

It may be possible to gain management support from within, but in order to accomplish this task you may have to educate them on the concepts and then show how implementation would be cost effective. Ms. Solai (See Section D of this Chapter) "sold the word-processing concept and system to line management, principals, and other employees through a series of seminars designed to educate them on the benefits of word processing."[64] Examples such as hers can prove quite helpful, especially in the earlier stages of TIS implementation before the technology and equipment have become familiar, common tools. After top management has been "educated"

to the potential in the concept of a TIS, the cost effectiveness of the system should be the convincing element that will elicit their continuing blessing.

However top management becomes involved in a TIS, either self-initiated or through internal pressures from members of the organization, the responsibility and authority to plan, design, and implement such a system will have to be delegated. The question will be, to whom? As has already been explained, both telecommunications and data processing functions are included, among others. Without an organizational structure that facilitates the cooperation of these two functions, the respective managers may simply end up at odds with each other, hindering progress or making it impossible. The same might prove true of the other specialties involved. It will be imperative, then, to address the issue of organizational change.

Today's corporation is ill structured to serve office needs. The telecommunications department has its specialties which are segregated from data processing, and likewise the administrative department. Each of these departments has varying qualifications and necessary contributions to offer to an efficient and cost effective TIS. The telecommunications department, for example, might know the technical specifications of the equipment and services offered, while the data-processing personnel would be knowledgeable in information transfer, storage, and retrieval. Administration interacts with both. So these should be included in the TIS structure. From earlier discussion the need for a fourth department, human resources development, was evident, and

should be involved in the decision-making process.

As TIS moves through the planning stages, a new department should be created to replace Administration called Office Information Systems. The knowledge and specialization needed to function in the more automated environment will necessitate this structural addition. Office Information Systems would interact with data processing and telecommunications on an equal footing in the revised organizations. The office organizational chart would then appear as follows:

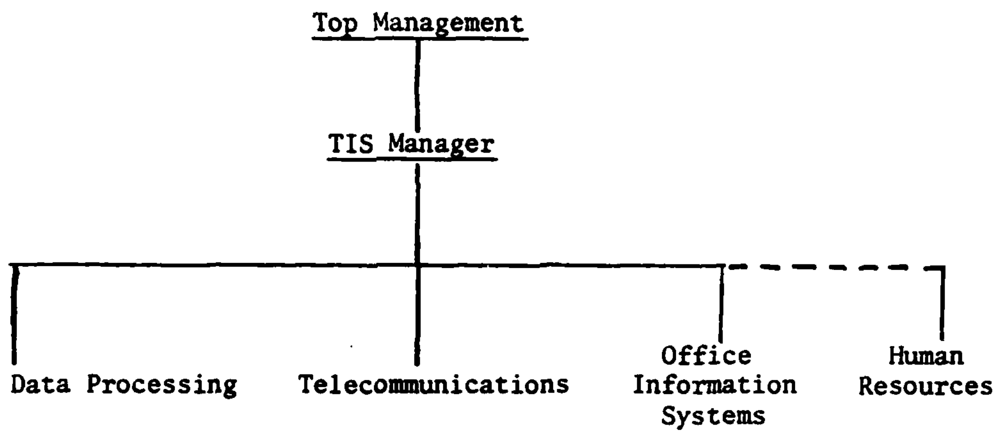

Figure 38. TIS organizational chart

As with implementing the system itself, changing the organizational structure will require a certain amount of planning and education. As Vydec's Mr. de Carargnac has stated:

> Systems inevitably cause some type of change in work patterns in an office. Disturbing relationships and procedures that have existed for years can be very traumatic for the people involved. A gradual shift towards the automated office with long-range objectives that everyone understands is imperative. Those who do not consider the future requirements and trends, and do not recognize the people aspect of change, the behaviorists point out, could produce not solutions but enormous and costly mistakes.[65]

The problem remains as to how to go about developing your system. Do you use the global concept or just start replacing equipment? Frost and Sullivan offer three methods for developing your system. They are:

1. Top-down development
2. Bottom-up development
3. Middle-out development[66]

Top-down development in their view involves getting a global view of a project. Many hypothetical situations and problems are posed but it is not until practical experience enters that concrete answers are received. "Experience is the best teacher," so it would be best that you get your feet wet without going over your head. In addition, with technology changing so fast, you might never get off the ground while conceiving that "perfect global picture."[67]

Bottom-up development consists of a building block concept. You begin with basic tools and then build upon them. The ultimate idea is that all pieces will fit nicely into the telecommunications picture. This can also be too idealistic due to the rapid growth and change of technology. With communications costs declining 11 percent per year, computer logic costs dropping 25 percent per year, and computer memory costs dropping 40 percent per year it[68] would be incorrect to view one piece of equipment or service as a lasting piece of the puzzle as it once was considered (refer to Figure 8).

The third method, middle-out is a balance of the first two methods. A TIS, using this approach, would be implemented not all at once nor in small segments. The main key to implementing

is flexibility, but the global concept should be kept in mind while passing through the implementing stages. In accordance with this idea, Jack E. Goldman, chief scientist at Xerox Corporation, stated that office systems "must be adaptable to changing requirements."[69] In addition, the system should be flexible so that exceptions can be dealt with plans to deal with effectively. Exceptions must be built into the system. It is always irrating to hear the excuse, "Your check is being processed through the computer and we'll have to wait until then."

TIS systems will be implemented only as the return on investment is sufficiently high to justify the capital expenditure. The "capital vs. labor trade off" logic will be used. This is just as valid for the office as it was for the factory and farm worker. With personnel costs rising and equipment costs falling, even a marginally cost-effective system (initially) may prove to be highly cost effecitve later (how long ago was gas selling for 30 cents a gallon?). We are beyond the "marginally cost-effective" point for many applications of the available technology, and this trend is certain to accelerate rapidly. Frost and Sullivan offer one case in which this is true, that is ". . . if a document is to be drafted once, automation is costly. If it is to be produced twice, then this is near break even. If multiple versions or revisions are needed, the automated system will be a big winner."[70]

In this dynamic industry, experience may well be the best teacher. Mistakes are possible, probable, but if the middle-out approach is used the harm can be minimized. As one authority has urged, concerning the need to begin an involvement with automated

office systems, "The most important thing for the neophyte is to get his feet wet."[71] To this might be extended an additional suggestion to those who have "gotten their feet wet" that they keep wading out into the "TIS ocean" until they can swim, in keeping with the evolutionary concept of moving to a fully integrated information system.

The middle-out approach will have the added advantage that flexibility can be planned for in the systematic movement to the desired goal of a mature TIS. The importance of flexibility in planning for automated systems has been emphasized repeatedly by authorities in the field. As one has stated it, "Equipment must be capable of being reconfigured as needs arise. It has to be flexible to allow for expansion and change, to perform a variety of technical functions."[72] The same principle should apply to the media intended for use as part of the integrated system. Networks, for example, should be flexible enough in design to accommodate changes in terminal equipment, computers, or circuit services.[73]

Network architecture should, in fact, not be designed around the hardware at all, but rather around the process or processes to be automated. A large-scale multi-application network, such as the larger versions of the TIS envisioned, will outlive the technology of the hardware originally installed in the network. For that reason, the architecture "should accommodate new hardware without disrupting service or degrading performance."[74] New interfaces must be capable of being added without affecting the user transparency of the system. In the past networks have been specific based on the physical characteristics of the terminal devices (characters, formats,

protocols, transmission rates, etc.), and it became extremely difficult, if not impossible, to upgrade these networks when improved hardware became available.[75]

Two considerations will make the network question less of a problem in the future (by the time a fully mature TIS is planned to be in place). The first is that protocols are trending towards standardization, and in the future digital networks which are evolving, the switching nodes "will be all digital, with a standard format."[76] The second is the intelligent network, which will transfer information independent of protocol (that is, information will be accepted in the protocol of the transmitter and delivered in the protocol of the receiver). In a recent article on the future capability of the public switched network, AT&T's Joseph Bader speaks of a "Stored Program Controlled (SPC) Network," not as a network separate from the existing one but as a method of augmenting the public network with improved technology. One of the main advantages, as Bader sees it, is that the SPC network will "be sufficiently versatile so that the user can have a broad range of choice of terminals to use, and the network can adapt to the customer's selection."[77] This network, along with the specialized networks in being or proposed, will be growing through the 1980s roughly keeping pace with the development of corporate and governmental integrated information systems. The former Chairman of AT&T, in his final report to shareholders, asserted that "we are well-launched on a thorough transformation of that network (the public switched network) into an 'intelligent' network, as useful for data as for voice. . . ."[78] If that proves to be true, the question of

flexibility in networks will cease to be a problem.

A final consideration, regardless of the approach chosen, is planning for increased system capacity. Too often, memory or physical capacity limits are reached soon after a system is implemented, resulting in costly additions. TIS has been proposed as an evolutionary, expandable configuration of individual modules, each with its own nodal intelligence, in a distributed environment. Capacity considerations would then revolve around the central processor(s) used with the system. With proper planning, "Expansion can be achieved by adding hardware modules while increasing the system's available processing and memory capacity."[79]

F. Conclusion

The needs for improved systems of information transfer, for organizations of all sizes, has been fairly well-established. Needs long unmet by the available technology and the installed systems, have become increasingly more urgent as management is faced with the additional problems associated with processing information, especially rapidly rising office costs. Attempts to solve management information needs and reduce the ever-mounting cost burdens associated with information have been hindered in the past by inadequate options from the market, regulatory inhibition of competition and innovation, and the cost of alternatives.

The barriers to solutions are rapidly falling. A wide variety of options is becoming available in the form of new media, new equipment, and new services, many of them at costs which are soon to be affordable by even the smaller organizations. For larger

companies, the communications pipelines with enormous capacities, such as SBS and XTEN, hold great promise. For smaller companies, the option of a digital, intelligent network such as ACS holds the potential of benefits that formerly were available only for companies able to afford the capital investment of a private network.

For small and large organization alike, the prospect of solutions through applying the available and future technology to past needs creates a new need--the need to plan for an integrated approach to the implementation of the new technologies. It is the contention of the authors that these solutions will not be found by selecting piecemeal a variety of separate and diverse systems or services. Rather, each element--each component--should fit into a long-range plan for a totally integrated-telecommunications system, a system which will be computer-based and digital, and will include all the information systems possessed by the organizations. Such a system has been named the "Telecommunications Information System" or "Total Information Systems" by the authors and proposed as a concept into which all the management information needs of the future could gradually be added on an evolutionary, modular basis as each component became cost-effective for the planning organization. As the elements are put into place, management will have to address the human problem and consider the needs of those who will use the information system as a tool or even the best technological solution will fail.

With the TIS approach, management will be able to begin now to develop the plans which will insure that information handling

needs of the future will be addressed, and solved, through an integrated approach, on a cost-effective basis, using the best technology that industry can provide. For the organization with such a view, the telecommunications future looks bright indeed.

CHAPTER IV

FOOTNOTES

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[7]James W. Driscoll, "New Organizational Design: A Behavioral Science Perspective on Office Automation," Sloan School of Management, Cambridge, Mass., March 21, 1979, p. 1.

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[11]James Martin, Telecommunications and the Computer, 2nd ed. (Englewood Cliffs, New Jersey, Prentice Hall, 1976), p. 3.

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[21]"Telecommunications Information System" is a term coined by Mr. Tom Cross of the Communications Institute of Boulder (CIB), Boulder, Colorado. TIS is also used to mean "Total Information System."

[22]"The Office of the Future," Journal of Systems Management, February 1979, p. 50.

[23]Ibid., p. 42.

[24]Zisman, op. cit., p. 24.

[25]Frost and Sullivan, op. cit., p. I-2.

[26]Zisman, op. cit., p. 4.

[27]Ibid.

[28]Ibid.

[29]Ibid.

[30]James H. Carlisle, "Evaluating the Impact of Office Automation on Top Management Communications," Yankee Group Second Annual Symposium on Electronic Mail, Cambridge, Mass., September 1978, p. 16.

[31]Frost and Sullivan, op. cit., p. I-8.

[32]Zisman, op. cit., p. 5.

[33]Zisman, op. cit., p. 7. Citing Shepard, "Automation and Alienation: A Study of Office and Factory Workers," Cambridge, Mass., MIT Press, 1971.

[34]Frost and Sullivan, op. cit., p. V-1.

[35]"1979 WP Executive: Leadership, Cost Effectiveness, Career Enhancement," Modern Office Procedures, June 1979, p. 77.

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[37]Ibid., p. 78.

[38]Ibid., p. 79.

[39]"WP in the Age of the Automated Office," Modern Office Procedures, June 1979, p. 68.

[40]Driscoll, op. cit., p. 8.

[41]"1979 WP Executive: . . ." op. cit., p. 75.

[42]Driscoll, op. cit., p. 12.

[43]"The Office of the Future,", op. cit., p. 8.

[44]Ibid.

[45]Ibid., p. 48.

[46]Philip G. Elam, "Considering Human Needs Can Boost Network Efficiency," Data Communications, October 1978, p. 51.

[47]Ibid.

[48]Interview with Professor Frank S. Barnes, University of Colorado, Boulder, August 6, 1979.

[49]Ibid.

[50]"The Office of the Future," op. cit., p. 47.

[51]Ibid.

[52]Driscoll, op. cit., p. 1.

[53]Ibid., p. 7.

[54]"WP Heads Toward Integrated Information Systems," Modern Office Procedures, January 1979, p. 110.

[55]Driscoll, op. cit., p. 10.

[56]Ibid.

[57]Ibid., p. 11.

[58]Ibid., p. 2.

[59]Ibid., p. 9.

[60]Frost and Sullivan, op. cit., p. I-3.

[61]"The Office of the Future," op. cit.

[62]Carlisle, op. cit., p. 20.

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[64]"1979 WP Executive: . . ." op. cit.

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APPENDIX

The following reprint of an article by Thomas E. Bolger, Executive Vice-President of AT&T appeared as part of a Business Communications supplement to the Forbes Magazine issue of July 9, 1979, too late to be used as a source reference for the Telecommunications Information System proposed in this paper. The Total Communications System (TCS) which Mr. Bolger proposes as a comprehensive, fully integrated office information system is based on much the same concepts as in our proposal, and system characteristics are remarkably similar, though less comprehensive.

Mr. Bolger addresses the role of information in U.S. society, and notes that professionals "cannot keep up with the literature," illustrating the growth in knowledge referred to in Chapter II. Information as a resource, the "raw material of thought and creativity," is another such concept. Mr. Bolger also emphasizes the evolutionary process involved in moving to his TCS, a process which was highlighted in several sections of this paper.

From an economic and technical perspective Mr. Bolger sees a need for speed, accuracy, reliability, responsiveness, and cost, a somewhat shorter list than the objectives cited in our Chapter IV, and the features from a user perspective are summed up by Bolger as a "multifunctional, transparent, and systematic," a list somewhat less comprehensive than our characteristics and objectives.

One concept included in TCS but not TIS is "Telework," the

decentralization of information work to remote branches or even worker's homes with large potential savings in commuting costs. This is fully consistent with TIS within the time frame we envision for a mature system and would appear to be a valuable addition to the total integration of information concept.

Mr. Bolger's projection of the marketing of integrated TCS systems by the middle 1980s is somewhat more optimistic than we feel is warranted by the evolutionary trend in automated offices and networking, even taking into account the recent rapid developments in media and the increasing rate of change in equipment technology. While hesitating to disagree, without better tools for prediction, our own survey and interpretation of current literature leads to a belief that Mr. Bolger is premature by several years in interpreting the rate of telecommunications evolution.

The similarities in both concept and implementation are much more numerous than the minor differences, however. Enhanced networks providing "multifunctionalism and transparency," "independent of the terminal architecture," modularity, system complexity, and the human aspects all receive emphasis in the TCS proposal equal to that in TIS. Mr. Bolger's article is, in sum, useful as a succinct summary of the concepts and system characteristics, as well as the implications, in the movement towards a totally integrated information system. Hence its inclusion in full.

BUSINESS COMMUNICATIONS

The carefully planned, well managed and fully integrated office information system now on the horizon promises to solve some of the most pressing problems confronting individual companies and the whole economy. But both vendors and users must bear in mind that only people can process information. Machines and systems support the people, not vice versa.

Thomas E. Bolger
Executive Vice President
AT&T

The telephone revolution began on March 10, 1876. Functionally, what happened on that famous evening was that one person, Mr. Bell, was able to communicate with and thereby influence the actions of another person, Mr. Watson, at a distance and in real time. This function—instant, inexpensive voice-to-voice communication—continues to evolve more than a hundred years later. Today virtually anyone can talk to anyone else anywhere in the world simply by pressing a few buttons.

As important as voice-to-voice telephone has been and will continue to be, we stand today on the threshold of another telecommunications revolution which will bring voice together with print, data, video and other media into comprehensive, fully integrated office information systems. Functionally, such systems will mean that virtually any business user will be able to originate, access, manipulate, transmit, store and retrieve any relevant information in any appropriate medium or combination of media. In the not-too-distant future these Total Communications Systems (TCS's) will be as pervasive as the telephone is in today's business environment. They will be reliable, flexible, inexpensive and secure. The technology is already well advanced and the economics are rapidly falling into place.

The problem for both vendors and users is in understanding the evolutionary strategies that lead efficiently from today's increasingly powerful stand-alone information offerings to tomorrow's integrated TCS's. There have been several false starts. Centralized typing pools and centralized data processing facilities, both fashions of the 1960's and early 70's, were, for example, driven by economic considerations alone. Neither took into account the way information really flows in an organization or the ways in which its human users cope with it. Consequently, neither realized the economic benefits that had been optimistically projected.

Almost unnoticed, the United States has become an information society. After a hundred years of gradual growth, information workers became a majority of the American work force in the mid-1970's. These are people with executive, managerial, administrative, professional, secretarial and clerical job titles. Behind these titles are functions which relate to the creation, use and management of information to control operations, make decisions and solve problems. Such people constitute about 52% of all workers and earn about two-thirds of all salaries and wages—currently about 47 million people making about $600 billion a year.

And the output of these workers is staggering. They make more than 100 billion telephone calls a year. They produce an estimated 72 billion documents and maintain another 300 billion, with a growth rate in excess of 20%. They spend an average of 12% of their working lives in face-to-face meetings.

By contrast, energy is a relatively small component of the Gross National Product. But with few exceptions, infor-

mation is not yet seen as a resource

It is. Indeed, it may be our most promising resource in the context of the productivity imperative. For just as oil, gas and coal are the raw materials which historically improved the efficiency of muscle power, information is the raw material of thought and creativity, of analysis and synthesis. Better planning, better decision making, better problem solving—which is to say, better management—will yield increased productivity. In each case, it is easy to define "better": faster, more accurate, more reliable, more responsive, less expensive.

With information seen as a resource, the question becomes: how do we best exploit it? Again, the answer is fairly easy: by developing tools or systems to facilitate information utilization. The key word is "utilization." As indicated above, we are already very good at producing information—so good that our computers and copying machines alone threaten to overwhelm us on a daily basis. To put the problem in perspective, consider the case of a single professional worker, say a physician. It is common knowledge that the doctor cannot possibly hope to "keep up with the literature," even the literature of his or her own specialty. Thus, we are faced with a dilemma: we can have either ever more specialized and more expensive medical service, or we can settle for treatment that is not up to date. Of course, there is another option. We can improve the productivity of the physician's information management system. But, in order to do that, we have to begin with the realization that the physician's function is to provide medical service, not to be an information systems engineer. We need to start with the user's operating function and determine how that user function can best be *supported* by information.

To date, the emerging information industry has focused its attention on information and communications as though either could be isolated from the human user. There have been perfectly good technical and economic reasons for this, but the result has been the proliferation of specialized stand-alone devices, many of which require the intervention of specialists between different parts of the needed information and the person who needs it. In recent years, it has become obvious that the opportunity lies in integrating these devices and/or their functions through communications links and communications processing capabilities. The extent to which such systems are designed around the information handling characteristics of human users will determine the extent to which the opportunity is realized.

All information starts and ends in a human mind. More importantly, the business purpose of information is to guide action, and people initiate, monitor and control every action. Machines do not process information and they do not communicate in any meaningful way. People do these things and they employ machines to support them. Thus, systems must fit people, not *vice versa*.

[illegible]

We have already admitted that we are nowhere near a Total Communications System in 1979. It appears likely, however, that TCS will be commonplace in business before the end of the century. Thus, the great question is: how do we get from here to there? We know that, from the economic and technical perspective we are looking for speed, accuracy, reliability, responsiveness and cost. From a user perspective, the list is somewhat different and may be summed up in three terms which have gained a measure of acceptance in the industry: multifunctional, transparent and systematic.

Multifunctionalism simply recognizes that information has many sources and many uses and that it comes in many formats and many media. Nevertheless, the federal government is continuing its regulatory efforts to draw the line between data processing and telecommunications. As Total Communications Systems emerge, the problem will be compounded. Word processing, copying and electronic filing will all be used with data processing as parts of the communication environment. Voice will be digitized and will become just another part of the total information stream.

All of these functions will interact electronically with each other. A voice command, for example, may generate either a video image or a hard copy or both in different locations. An engineer working on a schematic will be able to perform computations on a computer, translate the results into blueprint modifications, send copies to a test site and discuss them via teleconferencing with colleagues in remote locations. Of course, the same engineer does all these things today, but, in the process, calls upon multiple stand-alone devices and must spend considerable time translating from one to the next. In some cases, the translation process relies on costly personal travel or on the mails. And, in some cases, the potential for error in the translation process requires expensive redundancy.

Thus, a multifunctional TCS implies that a single system will serve all the information needs of any individual user.

The most obvious *thing about such a* system is its power. Given the perverse tendency of systems toward complexity, it will be essential to work toward simplicity of use. The industry word is "transparent," which implies that the operation of the system is invisible to its users. At present, the trend seems to be in the opposite direction. Even the telephone and the copier—marvels of user simplicity—show signs of requiring higher levels of *sophistication*. One reason that computers have never realized their full potential is that not enough people know how to use them.

Clearly, it will not be possible to reverse

this trend in systems that are designed to do more things. But, it will be possible to hide the complexity from the user by imbedding it in the system itself.

The term "systematic" is more difficult to describe. An idealized TCS would deliver a precisely tailored package of information services to every individual user. It would do so economically and with full security of private information. Since it must also be transparent, the network and its terminals must combine a high level of functional and control intelligence. Current architectural concepts such as "centralized" and "distributed" will probably have to be combined so that logical functions can be placed wherever they are most efficient for a particular application. Fortunately, the increasing power and decreasing costs of the underlying technology are beginning to make this possible.

The foregoing is clearly a view from the mountain—a projection which will hopefully provide a framework for planning the trip to the top. It is certainly the kind of thinking that is guiding the industry toward providing future communications solutions. It begins with the premise that the *integration* of information services will be accomplished through telecommunications. An elementary example of this is the telephone itself.

The evolution of voice service is crucial because voice is highly productive and universal medium of communications. Many companies are actively pursuing voice recognition today. The ultimate goal is voice-machine interaction and many observers predict that it is within the overall TCS horizon.

Another area of intense activity has been the integration of voice and data services. Of course, both the telephone and the network have been used for data transmission for many years. Integration implies that a user can perform both functions over the same line at the same time. For example, a distributor today can provide better customer service by providing immediate answers to customer voice questions from his data base. In the future, this same kind of service can be linked into multiple data bases, public and private, simultaneously.

In data communications, the industry is moving toward a network which will allow a wide variety of terminals to interact with each other regardless of their architecture. Thus, users will be able to select their terminals based solely on the particular application at hand in any location without needing a complex intermediate communications discipline. Moreover, the *communication capability* of the network will enhance the power of the terminal, with the user paying for the enhancement only on an actual usage basis. The promise of an enhanced network is a high level of multifunctionalism and transparency. Moreover, it is independent of terminal architecture and, therefore, fully supportive of the systematic concept.

The transparent network is a crucial step toward both private internal information systems and fully integrated TCS solutions. In this concept, the terminals, regardless of their function or functions, are not burdened with the complexity and expense presently associated with communications processing. Users are not burdened with the complexity and expense of multiple transmission networks.

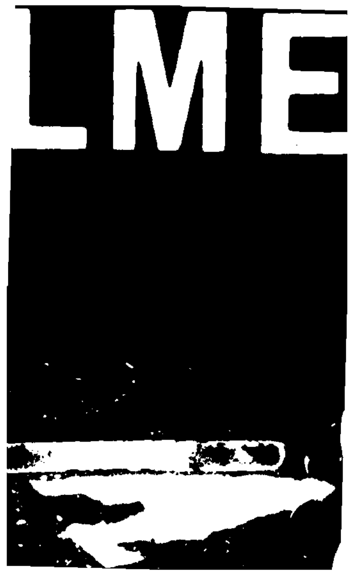
Everyone concerned with information has been struggling for many years to define and draw a picture of the office of the future. Only recently has something of a consensus developed; it will be an office with a single information system incorporating multiple applications and media. The system will support every information worker with exactly the right mix of capabilities that are easy to access and that can interact with each other. It will be an office in which the quality of decisions will be enhanced and the efficiency of operations improved by the flow of information.

And given the availability of total information support, the office may not be the only place where work gets done. Recently, several commentators have turned their attention to what is being called "Telework." In its various forms, this idea maintains that some substantial part of the information work can be decentralized to remote branches or even to the workers' homes. In some cases, there are good functional reasons to do this, as in the case of salespersons with particular geographic territories. But the most compelling argument is a social one. If we could reduce the amount of commuting between home and office, even by a modest amount, we would go a long way toward resolving the energy crisis and the nation's balance of payments deficit.

Telework is clearly a long term solution. In the short term, however, telecommunications can reduce the need for business travel. Again, there are graduated, evolutionary alternatives: the simple conference call, the teleconference which adds video, and facsimile and data communications which can add a wide variety of print to a long distance meeting.

The Office of the Future and the TCS concept itself are not nearly as distant, at least from the technical and economic points of view. Prototypes exist already and it would be surprising if integrated sytems were not being marketed by the middle of the 1980's. It is unlikely that these systems will be truly "total" in the sense described here, but they will clearly point the way.

The opportunity is nothing less than assuring the continuing growth of the American economy and the quality of life it supports.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